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Viable Alternative Types of Inspection/Maintenance Programs for St. Louis

GCA Corp, Bedford, Mass GCA Technology Div

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Viable Alternative Types Of Inspection/Maintenance Programs For St. Louis

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EXECUTIVE SUMMARY

This report presents the results of an analysis by GCA/Technology Division of alternative types of Inspection/Maintenance (I/M) programs for St. Louis. Its objectives are as follows: (1) evaluate alternative I/M programs in terms of cost and effectiveness, (2) develop detailed costs of selected alternatives as they relate to St. Louis City and County and estimate the effectiveness of each of the selected alternatives in reducing emissions of carbon monoxide and hydrocarbons for 1977, 1980, 1985 and 1990 for the entire St. Louis Air Quality Control Region (AQCR), and (3) develop an implementation schedule and highlight key issues associated with the implementation of each of the alternatives under consideration.

It is the purpose of this report to provide information to policy makers for use in their consideration of I/M as an air quality measure. Certain recommendations are made concerning key elements of I/M but no one alternative is recommended. Instead, as much objective information is presented as possible.

REPORT COVERAGE

The study area is the St. Louis Air Quality Control Region. This includes seven counties in Illinois (Bond, Clinton, Madison, Monroe, Randolph, St. Clair, and Washington) and five areas in Missouri (Franklin, Jefferson, St. Charles, and St. Louis counties and St. Louis City). EPA chose for purposes of this study to evaluate the emissions reductions for the entire Air Quality Control Region which would result if an I/M program were implemented in St. Louis City and County. This is not meant to imply that only St. Louis city and county will have such a program, but instead was done because of the large portion of the region's automobile registrations in these two areas.

The results from this analysis can be extrapolated for other areas of the Air Quality Control Region. In this report, such extrapolation is done for St. Clair and Madison counties in Illinois.

An I/M program involves the periodic inspection of motor vehicles to determine whether or not each vehicle is meeting certain standards for carbon monoxide and hydrocarbon emissions. This is the inspection phase of such a program. Vehicles which do not meet either or both standards are required to have the vehicle repaired (in most cases a carburetor adjustment) to bring its emissions in line with the standards. This is the maintenance phase of the program. While these two elements are common to any I/M program, a variety of organizations and testing options exist.

There were five alternative types of inspection/maintenance programs analyzed in detail. These are the following:

- Idle mode test conducted at state inspection stations.
- Idle mode test conducted at inspection stations operated by a contractor to the state.
- Idle mode test conducted at privately owned service stations and garages.
- Loaded test conducted at state inspection stations.
- Loaded test conducted at inspection stations operated by a contractor to the state.

RESEARCH METHODOLOGY

Emissions inspection/maintenance programs presently exist in seven states of the United States. A review of all aspects of these programs served as the foundation for this study. In addition to the quantitative information gathered in this way, the review of existing programs also allows for the identification of various practical problems associated with an I/M program. It was the avoidance of these problems that lead to the recommendations of this study.

Other technical information was obtained through a review of literature in the area of I/M. EPA, private companies, and academic institutions have performed studies on a myriad of I/M topics. These publications, listed in the bibliography of this report, provided information on the emissions reduction effectiveness of I/M, deterioration rates of automobile, emissions testing equipment, and program implementation considerations.

In order to present estimates as accurate as possible, a number of other sources were contacted. Cost estimates of the alternative programs are based upon information obtained from equipment manufacturers and Missouri State agencies as well as that data gathered from states having an I/M program. Estimates of the emission reduction attributable to I/M are based upon vehicle registration and mileage data specific to St. Louis city and county. A computer program written by GCA made use of these and other data to calculate the emissions reduction.

AIR QUALITY BENEFITS RESULTING FROM INSPECTION/MAINTENANCE

The effect of the I/M program is to reduce the exhaust emissions from the light-duty vehicles that are subject to the program. The estimated effectiveness data used were taken from the recent revision (Federal Register May 2, 1977) to Appendix N of the EPA Regulations for the Preparation, Adoption, and Submission of Implementation Plans (40 CFR Part 51). As shown by Tables 1 and 2, an I/M program implemented in St. Louis city and county would reduce carbon monoxide emissions in the AQCR by 21.6 percent in the year 1990 and hydrocarbon emissions by 6.6 percent in 1990.

Table 1. EFFECT OF INSPECTION/MAINTENANCE UPON CARBON MONOXIDE EMISSIONS IN THE ST. LOUIS AIR QUALITY CONTROL REGION

Year	Emissions without I/M, thousands of tons	Emissions with Mo. I/M,[a] thousands of tons	Percent reduction with Mo. I/M	Emissions with Mo. and Ill. I/M,[b] thousands of tons	Percent reduction with Mo. and Ill. I/M
1975	1259.3	N.A.[c]	—	N.A.[c]	—
1980	947.8	845.6	10.8	812.7	14.3
1985	663.2	535.1	19.3	493.7	25.6
1990	656.1	514.5	21.6	468.7	28.6

[a] Inspection/Maintenance in St. Louis city and St. Louis county only.

[b] Inspection/Maintenance in St. Louis city, St. Louis County, Mo.; Madison and St. Clair Counties, Ill.

[c] Not applicable since inspection/maintenance not implemented in 1975.

Table 2. EFFECT OF INSPECTION/MAINTENANCE UPON HYDROCARBON EMISSIONS IN THE ST. LOUIS AIR QUALITY CONTROL REGION

Year	Emissions without I/M, thousands of tons	Emissions with Mo. of I/M,[a] thousands of tons	Percent reduction with Mo. I/M	Emissions with Mo. and Ill. I/M,[b] thousands of tons	Percent reduction with Mo. and Ill. I/M
1975	205.7	N.A.[c]	—	N.A.[c]	—
1980	171.7	167.1	2.3	165.6	3.6
1985	127.6	119.1	6.7	116.4	8.8
1990	137.5	128.4	6.6	125.5	8.7

[a] Inspection/Maintenance in St. Louis city and St. Louis county only.

[b] Inspection/Maintenance in St. Louis city and County, Mo.; Madison and St. Clair Counties, Ill.

[c] Not applicable since inspection/maintenance not implemented in 1975.

Because the share of total AQCR emissions contributed by light-duty vehicle exhaust is smaller in the case of hydrocarbons than for CO, the overall effect of the I/M program is less. Other categories of emission sources, such as heavy-duty vehicles and evaporative losses, are not currently projected to decrease as rapidly as light-duty exhaust emissions. This is largely a matter of the historical priority with which they were attached, rather than because they are intrinsically more difficult to control. It is reasonable to presume that these other sources will subquently be further controlled.

COST OF INSPECTION/MAINTENANCE

Table 3 presents the estimated inspection fee for each alternative I/M program implemented in St. Louis city and county. Analyzed for three cases of number of stations licensed, the privately-run system's inspection fee is based on a station's annual cost divided by the number of vehicles inspected per station. To this the state's administrative cost per vehicle is added, yielding an inspection fee ranging from \$6.10 to \$7.30.

For the state-run and contractor-run inspection fees, the idle mode inspection fee ranges from \$3.90 for the state-run system to \$4.60 for the contractor run system. For the loaded mode alternatives the fee is \$5.25 for the state-run and \$6.25 for the contractor run.

The various costs associated with a network of inspection lanes at private service stations and garages are presented in Tables 4 and 5. The purchase price of an emission analyzer ranges from \$2000 to \$2500. This purchase comprises the total capital cost for a private garage as shown in Table 4. The operating costs vary depending on the number of stations in the network and are composed of the labor rate (including overhead) and maintenance of the equipment.

Table 3. ESTIMATED INSPECTION FEES

Type of system	Annual cost/ vehicle, $	Administrative cost/ vehicle, $	Profit/vehicle, $	Estimated inspection fee, $
Privately-run				
1500 stations	6.70[a]	0.60	-	7.30
1000 stations	5.90	0.55	-	6.45
500 stations	5.60	0.50	-	6.10
State-run				
Idle mode	3.75	0.15		3.90
Loaded mode	5.10	0.15		5.25
Contractor-run				
Idle mode	3.70	0.15	0.75[a]	4.60
Loaded mode	5.10	0.15	1.00	6.25

[a] Assumes 15 percent return on investment before taxes.

Table 4. CAPITAL AND ANNUAL COSTS ASSOCIATED WITH A PRIVATE GARAGE

	Number of stations licensed		
	1,500	1,000	500
Capital costs/stations	$2,500	$2,500	$ 2,500
Annual costs/station	4,100	5,400	10,300

Table 5. ADMINISTRATIVE COSTS OF A PRIVATELY-RUN SYSTEM

	Number of stations		
	1,500	1,000	500
Capital costs	$200,000	$176,000	$152,000
Annual costs	534,000	500,000	447,000

Table 5 shows that the administrative costs to the state will range from $447,000 to $534,000 per year. This is to cover not only the administration of the program but also surveillance, public relations, and mechanics' training programs.

Table 6 presents the total cost of a network of state and contractor run test lanes for each type of emissions test.

Table 6. TOTAL SYSTEM COSTS FOR STATE AND CONTRACTOR RUN TEST LANES

	Capital	Annual
State-run idle mode (33 lanes)	$4,595,000	$3,448,000
State-run loaded mode (44 lanes)	6,921,000	4,698,000
Contractor-run idle mode (33 lanes)	4,393,000	3,417,000
Contractor-run loaded mode (44 lanes)	6,089,000	4,667,000

IMPLEMENTATION SCHEDULE

Approximately 2 years are required from the adoption of the enabling legislation to the initiation of inspection if a state or contractor run system is selected. The breakdown of this is given in Figure 1.

The amount of time to establish an inspection/maintenance program using private facilities would take from 1 to 1-1/2 years from the adoption of the enabling legislation.

RECOMMENDATIONS

The following are recommended concerning the implementation of an inspection/maintenance program in St. Louis city and county.

1. Emissions testing should be combined with the existing Missouri safety inspection program in St. Louis City and County.
2. Vehicles should be tested on an annual basis.
3. For the immediate future, I/M should be limited to light duty vehicles (weight < 8500 lbs).
4. The following vehicle categories should be exempted from the inspection/maintenance program.
    - vehicles over 13 years old
    - new vehicles during the first year of registration
    - vehicles where the cost of emissions related repair work (exclusive of the repairs necessitated by the tampering with or disconnection of emission control devices) exceeds $75.
5. In the administration of an inspection/maintenance program efforts should be expended in the following areas.
    - public relations
    - consumer convenience
    - equity considerations

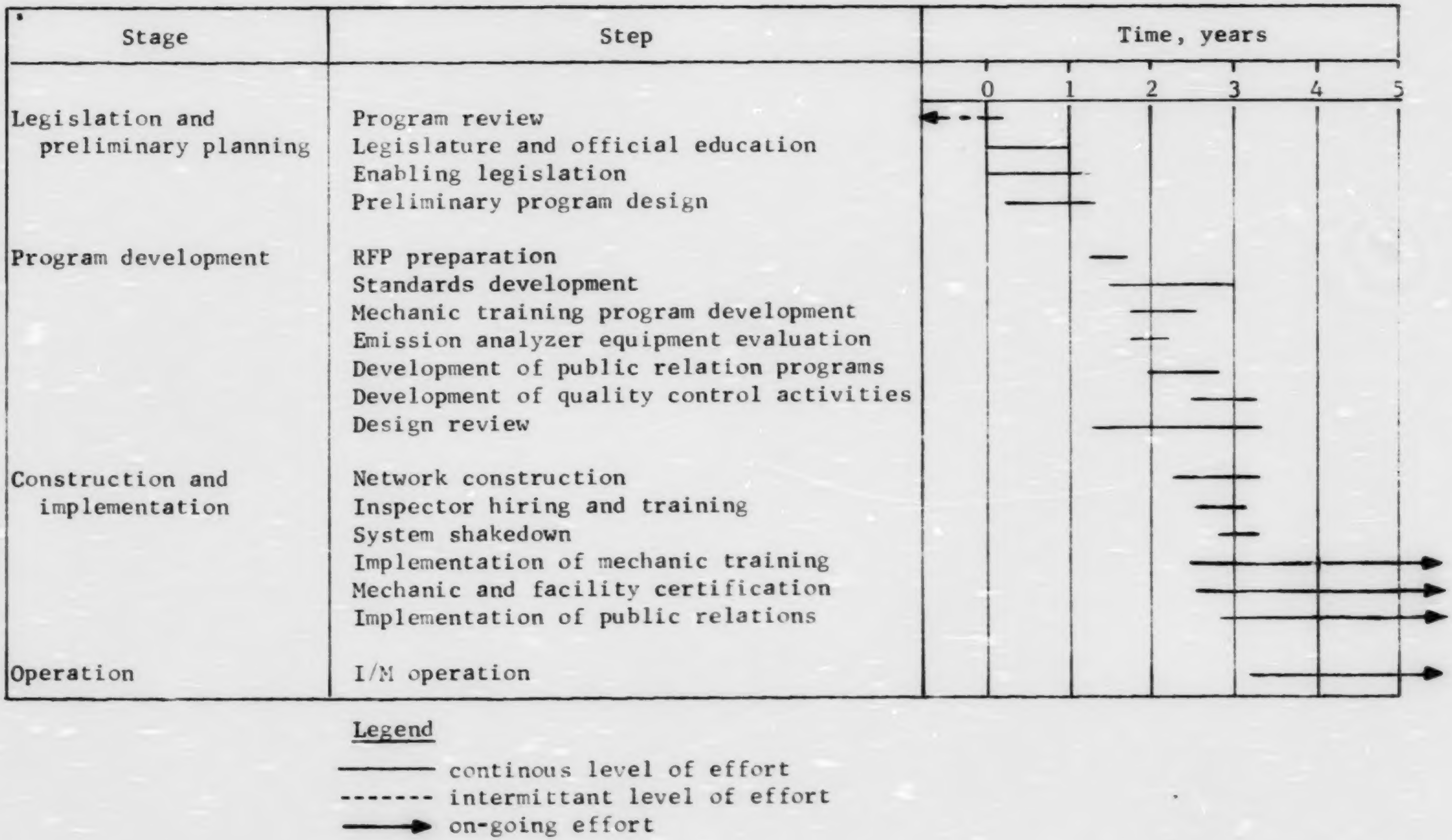

Figure 1. I/M implementation schedule for state or contractor run system

6. A training program for mechanics should be established to acquaint them with emissions related repair work.
7. Repairs shops should be certified by the state to perform emission related repair work.

GUIDE TO THE REPORT

This report consists of six sections and related appendixes.

- Section I surveys the report coverage and research methodology;
- Section II discusses the need for an inspection/maintenance program and presents the emissions reduction achieved;
- Section III presents background information on the technical and administrative aspects of inspection/maintenance programs;
- Section IV presents the cost analysis of the alternatives investigated for St. Louis city and county;
- Section V discusses in detail the benefits of inspection/maintenance;
- Section VI presents a schedule for the implementation of an inspection/maintenance program.

SECTION I

INTRODUCTION

A resolution adopted by the Missouri Air Conservation Commission in April 1976 included a provision for an emissions inspection/maintenance program (I/M) to be implemented in 1980 or 1981. Priority has been assigned to I/M because of its potential for reducing hydrocarbon emissions coupled with the few adverse impacts associated with such a program.

Essentially an I/M program involves the periodic inspection of motor vehicles to determine whether or not each vehicle is meeting certain standards for carbon monoxide and hydrocarbon emissions. This is the inspection phase of such a program. Vehicles which do not meet either or both standards must be repaired (in most cases a carburetor adjustment) to bring its emissions in line with the standards. This is the maintenance phase of the program. While these two elements are common to any I/M program, a variety of organizations and testing options exist.

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In order to present estimates as accurate as possible, a number of other sources were contacted. Cost estimates of the alternative programs are based upon information obtained from equipment manufacturers and Missouri State agencies as well as that data gathered from states having an I/M program. Estimates of the emission reduction attributable to I/M are based upon vehicle registration and mileage data specific to St. Louis city and county. A computer program written by GCA made use of these and other data to calculate the emissions reduction.

REPORT ORGANIZATION

The following chapters present in detail the analysis conducted. Section II discusses the need for an inspection/maintenance program in the St. Louis portion of the Air Quality Control Region. Background information on I/M is presented in Section III and includes both the technical and nontechnical aspects of these programs. Section IV presents the analysis of the alternatives investigated for St. Louis city and county. Section V discusses in detail the benefits of an I/M program. A tentative implementation schedule is provided in Section VI.

Appendices to this document present the calculations used to determine inspection lane requirements, costs of the inspection network, and emission reductions attributable to I/M. A bibliography and glossary are also included at the end of the report.

SECTION II

THE NEED FOR INSPECTION/MAINTENANCE IN THE ST. LOUIS AREA

This section discusses the need for air quality improvements in St. Louis city and county with emphasis on the extent to which an inspection/maintenance program would contribute to the attainment of clean air. The S[illegible] air quality situation is reviewed first. Next, the purpose [illegible] role of inspection/maintenance is discussed.

STRATEGIES FOR THE ATTAINMENT OF CARBON MONOXIDE AND OXIDANT AIR QUALITY STANDARDS IN ST. LOUIS

The Missouri State Implementation Plan (SIP) was submitted January 24, 1972. The SIP stated that ambient air quality standards for photochemical oxidants (O_x) would be attained by 1975 but that the standards for carbon monoxide (CO) would not be met. The data base for the control strategy for CO was a 1971 second-high, 8-hour average of 17.4 milligrams per cubic meter (mg/m^3). The projected reduction in CO, due to the Federal Motor Vehicle Emission Control Program (FMVECP), was not sufficient to meet the standard (10 mg/m^3) by 1975, but it was anticipated that the standards could be met by 1977. The strategy for O_x was based on a second-high 1971 1-hour value of 250 micrograms per cubic meter ($\mu g/m^3$). The plan demonstrated that the necessary hydrocarbon (HC) reduction would be achieved by the FMVECP and the O_x standard (160 $\mu g/m^3$) would be attained in 1975.

An analysis of 1972 air quality data showed a second-high, 8-hour CO value of 16.1 mg/m^3 and a second-high O_x value of 300 $\mu g/m^3$. Calculations based on these data showed that the FMVECP would not be adequate to meet the standards. Consequently, the Governor of Missouri was notified by EPA on September 14, 1973, that a SIP revision would be necessary, including the development of a Transportation Control Plan (TCP). It was requested that the plan be submitted on or before April 1, 1974.

The submission of the TCP was delayed several times, largely due to questions concerning the adequacy of the data base. A consultant was employed to develop an emissions inventory and to estimate the degree of emission reduction necessary. A special monitoring network was established during 1974. Instruments were maintained and calibrated on a schedule to assure that valid data would be obtained.

Examination of 1974 data showed a second-high, 1-hour concentration of 380 $\mu g/m^3$ for O_x and a second-high, 8-hour concentration of 12.4 mg/m^3 for CO. It was calculated that in order to meet the standards, O_x concentrations must be reduced by 58 percent and CO concentrations by 20 percent. The application of "Appendix J" indicates that a 65 percent reduction needs to be made in HC emissions. Current motor vehicle emission factors (AP-42, Supplement 5) indicate that the FMVECP will reduce HC emissions by only 23 percent in 1977, while CO emissions will be reduced by 28 percent in 1977 from the 1974 base-year.

Using this information to reinforce the need for additional control strategies, the request for SIP revision was repeated. Several public hearings were held, and on April 21, 1976, the Missouri Air Conservation Commission (MACC) adopted a resolution calling for the development of the necessary motor vehicle control strategies, and developed a schedule for their implementation. This resolution and time schedule was submitted by the Governor with a request that it be made a part of the SIP.

During the period from September 1973 when the call for a plan revision was first made, several things have been accomplished to promote its development. As noted earlier, a consultant developed an emissions inventory of HC and CO sources. The State developed and enacted a Phase I gasoline vapor recovery regulation. In addition, several projects have been completed, or are underway, to provide information to the general public and elected officials and to coordinate this plan development with other programs such as highways, waste water and land-use planning.

During 1974 a group known as the Traffic Advisory Committee (TAC) was formed at the direction of the Executive Secretary of the MACC. The TAC had representatives from the local air pollution control agencies, local and state highway departments, the local transit agency, industrial groups, the local interstate planning agency, and citizens and environmental groups. The TAC met monthly through 1975 and discussed implementation of HC and CO control strategies. As would be expected, there was large divergence of opinion on the need, and implementation techniques, for the various strategies. The TAC was extremely valuable in communicating the diverse opinions among the participating groups.

The East-West Gateway Coordinating Council (EWGCC), the areawide planning agency, participated extensively in the strategy development process. During the period when the TAC was active, EWGCC was under contract to EPA to develop strategies and to communicate the information to the MACC and other interested parties. The EWGCC participated in public hearings concerning the development of proposed control strategies. Due to the EWGCC's unique position as the areawide planning agency and experience in the development of the strategies to date, they have been selected as EPA's contractor to conduct a public information and elected official education program concerning air pollution in the St. Louis, Missouri area, with special emphasis on the automotive-related pollutant strategies. Work under this contract began in December 1976.

The resolution calling for adoption of HC and CO control strategies adopted by the MACC in April 1976, contained the following provisions:

1. Stage I gasoline vapor recovery regulation. This regulation has been adopted.
2. Dry cleaning and degreasing operations are being inventoried. Regulations, if necessary, will be developed.
3. Automobile painting, metal coating and other surface coating operations and possible control strategies are being studied.
4. An I/M program will be developed with implementation in 1980 or 1981.

The MACC decided to develop an I/M program only after several public hearings including one of 2 days which featured several specialists on the subject of photochemical O_x production and transport. At this particular hearing, EPA testified that the quantification of the reduction in O_x concentrations to be achieved by given reduction in HC emissions was very difficult, if not impossible. Going further, EPA testified that no guarantees could be made as to when the National Ambient Air Quality Standards (NAAQS) might be attained. Most important, though, was a demonstration that a reduction in HC emissions will reduce O_x concentrations and that a reduction in O_x concentrations will result in a reduction in health effects. Thus, it was shown that although the NAAQS might not be attained in the near future, if at all, the reduction of O_x levels would lead to fewer and less severe health effects.

With this in mind, the MACC plans to adopt strategies over a period of time as they can be developed. Those strategies which have the least adverse impact and provide the greatest reduction in HC emissions would be developed first. Thus, the priority assigned to I/M.

The MACC plans to develop and draft the necessary I/M legislation during 1977, find a sponsor(s) for the legislation, and put it before the legislature during the 1978 legislative session. This schedule will allow the maximum application of I/M experience gained in other areas to the St. Louis situation.

FEDERAL MOTOR VEHICLE EMISSION CONTROL PROGRAM

Title II of the Clean Air Act empowered the U.S. Environmental Protection Agency to promulgate and regulate emissions for new motor vehicles.[2] Emission standards were promulgated for that purpose. Title II of the Act is frequently referred to as the Federal Motor Vehicle Emission Control Program (FMVECP).

Emissions standards have been set but other programs are required to insure that in-use motor vehicles meet the specified standards. Three programs, administered by the Federal Government presently exist for controlling motor vehicle emissions. They are the following:

- Certification Program - certification of new vehicle prototypes to show that they are designed to meet emission standards.
- Selective Enforcement Auditing - assembly-line testing to assure that production copies of certified vehicles meet standards when new.
- Recall - requirement that manufacturers recall vehicle types found through in-use surveillance to fail standards because of defects in design.

The objective of these programs is to provide consumers with motor vehicles which can meet emission standards when the motor vehicles are properly maintained and operated. While it is the manufacturers' responsibility to produce motor vehicles engines with emission control devices and systems with no defects, the warranty provisions of the Clean Air Act do not provide for pollution-free or maintenance-free vehicles. Emission control devices, like other components of an automobile require periodic maintenance and adjustment.

Even with these federal enforcement programs, many vehicles are not meeting emissions standards for the following reasons.

- Not all vehicles can be inspected at the end of the assembly line. Vehicle types that pass certification may be assembled within reasonable tolerances but still produce many vehicles not meeting standards.

- Many in-use vehicles are tampered with. Emission control equipment may be deliberately disconnected and adjustments varied to affect vehicle performance.

- Many owners are ignorant of proper vehicle maintenance schedules and requirements. Vehicles which meet manufacturers' specifications would generally be low emitters.

INSPECTION/MAINTENANCE PROGRAMS

As pointed out above, if motor vehicles are to continue to meet emission standards after they have been in use, they must receive periodic maintenance. An inspection/maintenance program would ensure that motor vehicles are properly maintained. In short, inspection/maintenance is an integral part of a comprehensive motor vehicle emission control program. Its goal is to increase the frequency and quality of the maintenance of those engine components responsible for emission control and thereby reduce average emissions for the entire motor vehicle population. Thus, it supplements the Federal Motor Vehicle Emission Control Program.

Table 7 highlights the extent to which states have considered inspection/maintenance as an air quality measure. A total of 22 states have included inspection/maintenance in their State Implementation Plans and have conducted varying degrees of research into the matter. Legislation has been adopted in nine states which allows for various degrees of sanction to an inspection/maintenance program. Presently, seven states have implemented some form of an inspection/maintenance program. Appendix D presents fact sheets on these programs.

REFERENCES

1. Transportation Control Strategies for the St. Louis Metropolitan Area. Prepared by the East-West Gateway Coordinating Council under a grant to the Missouri Department of Natural Resources by the U.S. Environmental Protection Agency. April 1976.

2. 42 USC, The Clean Air Act, Title II - Emissions Standards for Moving Sources. Part A - Motor Vehicle Emission and Fuel Standards. Establishment of Standards, Sec. 202. (1957 et seq.).

Table 7. EXTENT OF STATES' CONSIDERATION OF INSPECTION/MAINTENANCE

State	City	Strategy requirement SIP	Preliminary review or research	Enabling legislation	I/M Implementation
Alaska	Fairbanks	X	X		
Arizona	Phoenix	X	X	X	X
	Tucson	X	X	X	X
California	Los Angeles	X	X	X	X
	San Diego	X	X		
	San Joaquin	X	X		
	San Francisco	X	X		
	Sacramento	X	X		
Colorado	Denver	X	X		
Connecticut	All	X	X		
Illinois	Chicago	X	X	X	X
Indiana	Indianapolis	X	X		
Maryland	Baltimore	X	X		
Massachusetts	Boston	X	X		
	Springfield	X	X		
Michigan	—		X		
Missouri	St. Louis	X	X		
New York	New York City	X	X		
New Jersey	All	X	X	X	X
Nevada	Las Vegas	X	X	X	X
Ohio	Cincinnati	X	X	X	X
	Dayton	X	X		
Oregon	Portland	X	X	X	X
Pennsylvania	Philadelphia	X	X	X	
	Pittsburgh	X	X	X	
Rhode Island	All	X	X	X	
Texas	Houston	X	X		
	Dallas	X	X		
Utah	Salt Lake City	X	X		
Virginia	—		X		
Washington	Seattle	X	X		
	Spokane	X	X		
	District of Columbia	X	X		

ADDENDUM

Contract No. 68-02-1376, TO No. 28

VIABLE ALTERNATIVE TYPES OF INSPECTION/MAINTENANCE PROGRAMS FOR ST. LOUIS

Table 7. EXTENT OF STATES' CONSIDERATION OF INSPECTION/MAINTENANCE

State	City	Strategy requirement SIP	Preliminary review or research	Enabling legislation	I/M implementation
Alaska	Fairbanks	X	X		
Arizona	Phoenix	X	X	X	X
	Tucson	X	X	X	X
California	Los Angeles	X	X	X	X
	San Diego	X	X		
	San Joaquin	X	X		
	San Francisco	X	X		
	Sacramento	X	X		
Colorado	Denver	X	X		
Connecticut	All	X	X		
Florida	Tampa		X		
Illinois	Chicago	X	X	X	X
Indiana	Indianapolis	X	X		
Kentucky	Louisville		X		
Maryland	Baltimore	X	X		
	D.C. metro area	X	X		
Massachusetts	Boston	X	X		
	Springfield	X	X		
Minnesota	Minneapolis		X		
Missouri	St. Louis	X	X		
New York	New York City	X	X		
New Jersey	All	X	X	X	X
Nevada	Las Vegas	X	X	X	X
	Reno	X	X	X	
Ohio	Cincinnati	X	X	X	X
	Dayton		X		
Oregon	Portland	X	X	X	X
Pennsylvania	Philadelphia	X	X	X	
	Pittsburgh	X	X	X	
Rhode Island	All	X	X	X	
Tennessee	Nashville		X		
Texas	Houston	X	X		
	Dallas	X	X		
Utah	Salt Lake City	X	X		
Virginia	D.C. metro area	X	X		
Washington	Seattle	X	X		
	Spokane	X	X		
	District of Columbia	X	X		

SECTION III

OVERVIEW OF VEHICLE EMISSIONS INSPECTION PROGRAMS

The various technical and administrative factors which influence the cost and effectiveness of a vehicle emissions inspection program are discussed in this section. First, the two major types of emissions inspection programs are defined. The next section reviews alternate administrative approaches and emission inspection procedures. The factors determining the emissions reduction potential of an emission inspection program are identified after this. Finally, the administrative factors of an inspection program are discussed.

In the discussion that follows recommendations are made, where appropriate, as to desirable courses of action. The recommendations listed in the Executive Summary are thus explained in this section.

TYPES OF VEHICLE EMISSIONS INSPECTION PROGRAMS

The two major types of vehicle emissions inspection programs are inspection/maintenance programs and a mandatory maintenance program.

An Inspection and Maintenance program consists of two phases:

- Inspection - Vehicles are inspected to determine if emission levels conform to predetermined emission standards. Those vehicles requiring maintenance to bring them into conformance with emission standards are identified.

- Maintenance - Engine malfunctions causing excessive emissions are corrected. Vehicles failing the first inspection are then reinspected.

A mandatory maintenance program requires all vehicles to undergo specific maintenance procedures designed to assure compliance with emissions standards. The maintenance is performed by authorized garages. Under a mandatory maintenance program the inspection phase is entirely avoided. While this aspect is intuitively appealing, it eliminates the very feature essential to any emissions control program — namely the ability to monitor the vehicles. If a mandatory maintenance program is to be effective, there then must be a way of checking to see that the maintenance work has succeeded in reducing emissions. In order to do this, the use of an emissions analyzer is essential. In conclusion, mandatory maintenance programs are considered undesirable because of the fact that the elimination of the inspection phase prevents a check on the adequacy (in terms of emissions) of the maintenance performed.

Based upon the above reasoning and after consultation with the U.S. EPA Project Officer and officials from the State of Missouri and the St. Louis area air quality agencies, the decision was made to eliminate mandatory maintenance from any further consideration. Therefore, the remainder of this report deals only with alternative inspection/maintenance programs.

ALTERNATIVE INSPECTION/MAINTENANCE PROGRAMS

There are five recognized alternative types of inspection/maintenance programs. These are the following:

- Idle mode test conducted at state inspection stations.
- Idle mode test conducted at inspection stations operated by a contractor to the state.
- Idle mode test conducted at privately owned service stations and garages.
- Loaded test conducted at state inspection stations.
- Loaded test conducted at inspection stations operated by a contractor to the state.

As displayed by the above listing, there are two items which are necessary to define an I/M system. These are the nature of test and the way that the test is administered.

Nature of the Emissions Test

The minimum requirements of an in-use vehicle emissions test are that it be short, applicable to warmed-up vehicles, and able to identify high emitting vehicles. Two distinct emission testing procedures which satisfy these criteria have been developed for measuring exhaust emissions. These are the idle mode and the loaded mode tests. They have been the only short tests used in programs directly affecting the inspection of vehicles owned and operated by the general public.

The idle mode test is the test of the exhaust emissions with the vehicle in a neutral gear and the engine at idle. Often, hydrocarbon (HC) and carbon monoxide (CO) levels are recorded at both a normal and a high idle speed. The test at the normal idle speed is taken at the manufacturers' recommended idle, measured in revolutions per minute (rpm), and then the engine speed is increased to 2,250 (± 10 percent) rpm for the high idle speed test. The standards must be met at both levels.

The loaded mode test is the test of the exhaust emissions with the vehicle in a forward drive gear and operating at simulated driving conditions. Pollutants are measured at various test conditions as specified by a testing procedure. Usually there is a test of emissions at high cruise (50 mph), low cruise (30 mph) and idle. As with the idle test, an emissions analyzer is used to measure emissions level. In addition, a chassis dynamometer is used in the loaded mode test to simulate the driving conditions mentioned.

Loaded mode testing is a better indicator of actual emissions since it involves the simulation of actual driving conditions. In addition, the simulation has the capability to provide better diagnostic information to a mechanic in terms of actual engine maladjustments and malfunctions. These advantages come at the expense of greater testing cost due to the need for a chassis dynamometer. The time required to test a vehicle is also increased.

The idle mode test also provides a viable method for identifying vehicles with high emission levels. This test procedure is simpler to perform and requires less technician training. Inspection lanes which use the idle mode test will have a greater capacity and thus will result in lower costs per vehicle inspection. An additional advantage of this test is that it can be easily duplicated at service garages to confirm emission maintenance. The idle mode test is generally not considered as effective as the loaded mode test, but other considerations, such as cost, may warrant selection of this test procedure.

Table 8 summarizes the characteristics of idle and loaded mode testing procedures. The U.S. EPA and private research organizations have found idle mode testing to be almost as effective as the loaded mode test in identifying gross emitters, and thus a viable inspection technique.[1-3]

Administration of the Test

An I/M program can be conducted at either a network of centralized inspection lanes or a network of certified private garages. A public authority can be delegated the responsibility of establishing this network of inspection lanes, or contractor may be commissioned to design, finance, construct and operate the program. The contractor would be selected through a competitive bid process and would be monitored by and accountable to the responsible state agency. A third alternative is to license and certify private service stations and garages to operate the program using their existing facilities. These facilities would also be monitored by and accountable to the public authority responsible for overall program administration.

Table 8. CHARACTERISTICS OF IDLE MODE AND LOADED MODE TESTING

Idle mode testing	Loaded mode testing
1. Simple test procedure which requires minimum training for operators	1. Engine operated under simulated road cruise conditions
2. Carburetor adjustments can be made during test	2. Includes idle test
3. Diagnosis of some engine maladjustments and malfunctions	3. Additional diagnostic information to repair facility
4. Can be duplicated by either public or private test systems	4. Requires dynamometers and other additional equipment
5. Requires minimal test time and equipment	5. Test cannot be duplicated in most repair facilities due to lack of dynamometer
6. Malfunctions that occur under loaded conditions may not be detected	6. Requires more test time

Table 9 provides a comparison of the three alternative administrative approaches. The private garage approach provides the greatest convenience to the public. Since inspection and maintenance can be accomplished with one stop, indirect costs to the consumer are minimized. Test lanes constructed by governmental authority are designed for high capacity. This high capacity and the economy of constructing multilane testing centers can result in lower inspection costs. In addition, a central test lane approach lends itself to simplified data handling and better quality control. A private firm contracted by governmental authority to construct and operate the facilities reduces the financial burden of raising public funds for capital investments. Other points of comparison are listed in the table.

The U.S. EPA has developed estimates of the potential emissions reduction benefits likely to be achievable by an I/M program. While basic requirements are identified for both the central test lane and private garage

Table 9. CHARACTERISTICS OF ALTERNATIVE WAYS TO ADMINISTER AN INSPECTION/MAINTENANCE PROGRAM

State inspection stations	Contractor operated inspection stations	Privately run service stations and garages as inspection stations
1. Designed specifically for high capacity emission testing	1. Same as 1 to 7 for State inspection stations	1. Less travel time for the vehicle owner
2. Economy of multilane inspection stations - inspection fees lower	2. Industry operation more efficient; flexible decision making capability	2. Minor adjustments can be made at time of inspection
3. Simplified data handling and processing due to a minimum of facility collection points	3. Reduces financial burden of state - capital investment	3. Large number of stations - greater convenience
4. Effective monitoring of repairs and maintenance	4. State administrative functions extensive and costly	4. Reduces financial burden of state - capital investment
5. Greater quality control potential	5. Additional travel for consumer's vehicles which fail test	5. Frequent use of highly trained and paid personnel for test performance - cost issue
6. Diagnostic recommendation by trained personnel	6. Long lead time for construction and operation	6. A large number of private stations required
7. Benefits from computer applications (e.g., data handling and processing)		7. State administrative functions most extensive and most costly
8. Additional travel for consumer's vehicles which fail test		8. Nonuniformity of enforcement criteria
9. Longest lead time for construction and operation		9. Data handling and reduction more cumbersome
10. Significant initial expenditure of state funds for capital investment		

approaches (and must be met to obtain full credit for potential emission reduction). The provisions for the private garage approach are more comprehensive. Unless a privately-run system is extremely well run and administered (as specified by EPA) greater effectiveness will result from a publicly operated or contractor operated I/M program.

I/M OF HEAVY DUTY VEHICLES

I/M of heavy-duty vehicles (HDV's) is best accomplished separately from light-duty vehicles (LDV's) because of the variation in the technology required to test the emissions of the two vehicle classes. In contrast to LDV's, there exists an extremely wide range in the types, weights, and uses of heavy duty vehicles which affect the emission characteristics of each vehicle. In this regard, federal emission regulations have been provided for the engines used to power the HDV rather than for the type of vehicle, as is the case for LDV's. HDV engines have less sophisticated emission control equipment than the typical passenger vehicle. The result of this is that the emissions from a heavy-duty vehicle is much greater (on the order of 3 to 4 times) than the average light-duty vehicle.

There are special considerations to be weighed when devising an I/M program which would include the testing of emissions from heavy-duty vehicles. Among these considerations are the following factors:

- The number and density of heavy-duty vehicles in the region
- The range of types, weights and uses included in the vehicle population
- Applicable emission standards and test procedures
- Fleet operation and scheduled maintenance are more common for HDV than LDV

These considerations in general do not favor the use of the centralized I/M approaches for the testing of heavy-duty vehicles. It appears that a mandatory periodic maintenance program is more practical. In addition, an emission test for HDV that is both low in cost and of short duration is difficult to devise and to perform.

Experience of I/M for HDV of in-use vehicles is, relative to LDV, minimal. Arizona includes the testing of HDV's in its I/M program. Both New Jersey and Oregon have proposed programs to be initiated during 1978 to inspect heavy-duty vehicle emissions. In both states, the proposals outline the development of activities separate from the respective state's LDV I/M programs. New Jersey's program calls for self-inspection by the HDV owners with the standards enforced by spot checks on the road (i.e., pullover) and at the operators' facilities. The intent of this program is to effect an improvement in the maintenance of engine emission parameters.

From the above discussion it is recommended that HDV be excluded from the initial stages of an I/M program in the St. Louis area. Emission testing of HDV could be incorporated at a later date after experience with LDV I/M is gained in the St. Louis area and after further experience with the testing of HDV is accumulated and documented by others.

DETERMINING FACTORS OF EMISSIONS REDUCTION FROM AN INSPECTION/MAINTENANCE PROGRAM

The emissions reduction resulting from an inspection/maintenance program is dependent upon the frequency of testing, the emission standards selected, and the number of vehicles covered by the program.

Frequency of Testing

In order to determine how frequently vehicles should be inspected for emissions, it is necessary to know something about how long emission related repair work - such as correction of carburetion - is likely to last. The increase in emissions from the time of repair or tune-up is known as deterioration. Several studies have been conducted in this area

area[4,5,6] It has been found that within 6 to 9 months the emissions from repaired vehicles are at the level that existed prior to when the adjustments were made. Figure 2 is a plot of emission deterioration from one of these studies.[5] It depicts the time interval in which post-tune-up emissions deteriorate to pre-tune-up levels. Obviously, once pre-tune-up levels are reached, further maintenance is required to offset continued deterioration.

It would appear that based upon these deterioration studies a semiannual inspection would be warranted to minimize emissions. While this constitutes a model inspection frequency, it is our recommendation that vehicles be tested only once a year. This is based upon both pecuniary and public acceptance considerations. A semiannual inspection would necessitate twice the number of inspection lanes as needed with an annual inspection. This would involve substantially higher program costs. Further, a twice-a-year emissions inspection would be more difficult to combine with the existing yearly safety inspection in Missouri. If the public were required to have their vehicles inspected on three separate occasions during the year - once for safety and twice for emissions - the acceptance of the program would be hindered.

Emission Standards

The standards established for carbon monoxide and hydrocarbon emissions are a second factor determining the overall emissions reduction from an inspection/maintenance program. It is the standards established which determines the number of vehicles requiring repair and hence, the total reduction in emissions which result from these repaired vehicles.

There are several ways to determine the emissions standards. All require information on emissions from different age vehicles and the number of registered vehicles for each model year. The actual collection of the data necessary for such calculations can be a time-consuming undertaking which involves the testing of emissions from a statistically acceptable sample of the population.

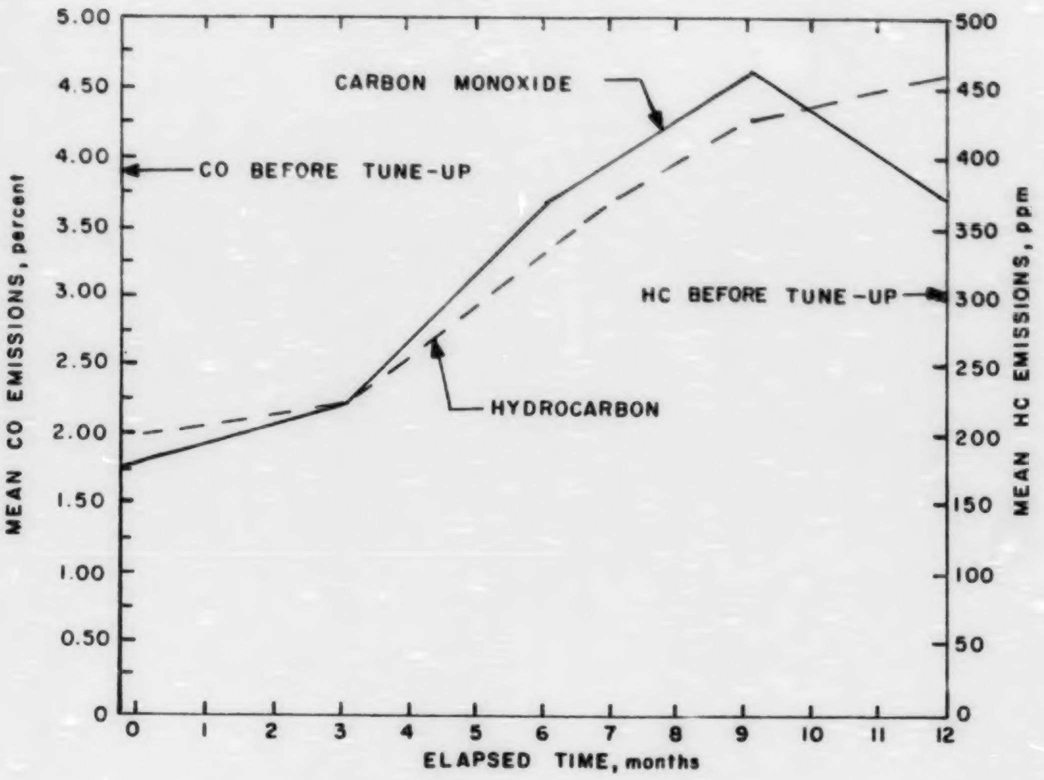

Figure 2. Exhaust emission deterioration[10]

Assuming that the vehicle population in St. Louis City and County is not significantly different from other areas of the country and that emissions for a given model year are not significantly different, a great deal of effort can be saved in establishing emissions standards by using the standards established in states having an inspection/maintenance program. Table 10 presents these standards for five areas of the country. As shown by the title, the emissions standards of different states are very similar. It is our recommendation that the emission standards established for St. Louis City and County be similar to those found in these areas.

Number of Vehicles Inspected

The number of motor vehicles actually inspected is the third major factor affecting emission reduction. This total is not necessarily equal to the registered vehicle population because some vehicle classes and types may be exempt from the program. The effective vehicle population is then defined as those vehicles registered within the intended service area that are required to comply with the emission standards.

There are several reasons for exempting certain vehicles from an I/M program. Some of these are listed below.

- Reduce potential hardships to owners of older vehicles or special purpose vehicles. (Age limits or special registrations)
- Eliminate the potential of effecting the value and glamour of antique vehicles. (Special antique exemptions)
- Optimize cost-effectiveness by restricting effective vehicle population. (Registration of new vehicles)
- Eliminate undue economic hardship by limiting the cost of repairs. (Price ceilings are required.)

In addition, the emission reduction potential of an inspection/maintenance program also depends upon the geographic area to be included in the program. As stated earlier, this report deals with just St. Louis City and County.

Table 10. TYPICAL EXHAUST EMISSION STANDARDS – IDLE TEST

Locale	Model year	CO, percent			HC, ppm		
Nevada	Pre-1968		7.5			1200	
	1968-1969		5.0			600	
	1970		4.0			400	
	1971 and later		4.0			400	
Cincinnati	Pre-1968		6.0			1000	
	1968-1969		5.0			600	
	1970-1974		4.0			500	
	1975 and later		1.5			250	
		Phase I	Phase II	Phase III	Phase I	Phase II	Phase III
New Jersey[a]	Pre-1968	10.0	8.5	7.5	1600	1400	1200
	1968-1969	8.0	7.0	6.0	800	700	600
	1970-1974	6.0	5.0	4.0	600	500	400
	1975 and later		3.0	2.0		300	200
Portland, Ore.[b]	Pre-1968		6.5			Varies	
	1968-1969		4.5			800	
	1970-1971		3.0			700	
	1971-1973 Capri		3.5			-	
	1972-1974 4 cyl.		3.0			600	
	1972-1974 6&8 cyl.		2.0			500	
	1975 and Catalyst		1.0			150	
	later Noncatalyst		1.5			225	
Chicago	Pre-1968		6.0				
	1968-1969		5.0				
(Nonfleet)	1970-1974		4.0				
	1975 and later		1.5				

[a] New Jersey is using a phased approach in its program. Standards were more lenient at the outset of the program and are made gradually more stringent.

[b] Portland's standards vary with make, model, weight, emissions equipment. Ford motor products shown in table as example.

It is our recommendation that the following vehicle categories be exempted from an inspection/maintenance program in St. Louis City and County.

- Vehicles over 13 years old
- New vehicles during the first year of registration
- Vehicles where the cost of emissions related repair work (exclusive of repairs necessitated by the tampering with or disconnection of emission control devices) exceeds $75

It should be emphasized that the above exemptions improve the acceptability of an inspection/maintenance program and are unlikely to significantly reduce the overall emissions reduction potential of the program.

ADMINISTRATIVE FACTORS

Based on the experiences of existing inspection/maintenance programs, certain nontechnical aspects have been found to be essential in assuring the smooth and successful functioning of an I/M program. Regardless of whether the program is privately-run, state-run, or contractor-run, it is imperative to elicit the cooperation and support of the repair industry and vehicle owners. It is our recommendation that in the administration of an I/M program, efforts should be made in the following areas:

- Public relations
- Consumer convenience
- Equity considerations

Public Relations

The public relations program serves to familiarize the public and the repair facility owners with their roles in an I/M program. A PR campaign is required to explain objectives of I/M as well as its air quality and fuel conservation benefits. The actual test procedure should be described to inform vehicle owners and mechanics of the means selected to inspect the vehicles. The public should be assured that most vehicles will pass the test and that most of those that fail will require only minor maintenance. It should be pointed out to all vehicle owners that the repairs necessary to pass inspection will keep the vehicle in better running order and prolong its useful life. Another function of the PR program is to provide vehicle owners with information regarding station locations, inspection times, and consumer protection measures.

Directors of current I/M programs recommend that PR programs be started 6 months to a year before mandatory testing is begun to allow vehicle owners to become accustomed to the concept of I/M. In Arizona the PR program was not fully established until after the start of mandatory testing. As a consequence of this, the Arizona I/M program experienced considerable public opposition in its early stages. This was also the case in Cincinnati where I/M was implemented in one step with no time allowed for public familiarization.

Public relations can be conducted in a variety of ways. The media are a valuable tool for the distribution of information since program details can be transmitted to a large segment of the population through advertisements, news accounts, and public service announcements utilizing local radio and television stations and newspapers.

A useful method of informing people of station locations, operating and consumer protection measures is to send brochures containing this information to vehicle owners when they are notified to have their vehicles inspected. An audio visual production should be prepared for presentation to small groups, such as the League of Women Voters, fraternal organizations, automobile clubs, and environmental groups. When I/M is fully operational an information flow between the state and the repair industry should be maintained to keep all parties aware of program developments and problems being encountered.

Consumer Convenience

An I/M program will be more readily accepted by vehicle owners if their inconvenience in terms of travel and waiting times is minimized. Ideally the average distance travelled by a vehicle owner to an inspection station is 5 miles while a 10-mile travel distance is a reasonable objective as an upper limit. Proximity to local community activity centers is desirable in locating stations. The actual number of stations has a great impact on accessibility and waiting times.

For a central test lane configuration, providing the option to retest at a private garage can reduce consumer travel and waiting time. A vehicle owner can have his car reinspected at the same facility that performs the repairs and eliminate a second trip to the test station.

The time period between notification of required inspection and the compliance date should be designed to allow ample time for inspection, maintenance and reinspection. It was Arizona's experience that 30 days was not enough time; the legislation has subsequently been revised to permit vehicle inspection during the 90 days prior to registration renewal.

Equity Considerations

In addition to being convenient, an I/M program should be as equitable as possible. An effort should be made to reduce any undue financial burden caused by the program and to allay any public fear about unscrupulous repair facilities. Elements of a program to achieve this objective are:

- Mechanic training and certification
- Repair facility licensing
- Consumer protection

Mechanic Training and Certification - Mechanic training increases the efficiency of the repair industry performance and is prerequisite to the effective testing and proper maintenance of vehicles. Familiarity with the test procedure and equipment promotes objective and competent testing as well as insuring that testing is uniform and consistent among stations. Mechanics need to understand the functioning and maintenance of air pollution control devices in addition to knowing which engine parameters affect emissions and how to tune to minimize emissions.

Mechanic training helps alleviate the problems of ineffective repairs and excessive repair. The latter is caused by overadjustment by an uninformed mechanic in an effort to avoid missing the problem. California has developed a mechanics' handbook which describes a repair sequence, or step by step procedure, for each type of emissions failure. Mechanics are instructed to proceed only as far as the step that corrects the malfunction. This California program was developed to meet a legislative requirement that garages repair vehicles according to specifications established by the Bureau of Automotive Repair. The specifications are an attempt to eliminate the guesswork involved in repairs and also serve as a basis for the evaluation of repair work. (California had a guarantee program in effect which required that additional repair work be performed at the garage's expense or the customer's original payment be refunded, at the customer's option, if the initial repair work was not conducted according to the state specifications. This program has been revised since it was found unworkable because of the time period allowed to consumers to exercise their option and because of consumer tampering. The state now has recourse to those mechanics who frequently perform unsatisfactory repair work.)

A training program should be composed of an informational seminar and technical workshops in which mechanics can gain practical experience. Colorado State University has developed a program of this type under the sponsorship of EPA. Mechanic certification should be based on the test scores from a written examination administered by the cognizant government agency. Preparation for the test would involve participation in a technical training session or course work at a local technical school.

The Missouri State Highway Patrol currently administers an examination for mechanic certification for safety inspection. The prerequisites for certification include 1 year's experience as an automobile mechanic or the successful completion of a course on the subject at a technical training school. The written examination, which tests the mechanics knowledge of the safety inspection regulations and specifications, may be accompanied by an examination of practical knowledge in which the mechanic performs a safety inspection.

Repair Facility Certification — Having repair facilities certified to perform repair work is another aid to the consumer whose vehicle requires emission related work. The criteria for a repair establishment to obtain certification should be having a certified mechanic on the staff and purchasing a state-approved emissions analyzer. Certification serves two purposes: it gives vehicle owners some guarantee of the credibility and competence of the repair facility and it acts an an incentive to the industry since a repair establishment would be more inclined to perform effectively to retain its license. The state should, in turn, inform vehicle owners of the merits of having their cars repaired by a licensed garage.

Consumer Protection - Provisions must be made to insure that vehicle owners are protected from abuses which could appear in the system (e.g., overcharging by repair shops and unnecessary repairs) just as care must be taken to avoid hardships in terms of extremely costly repairs or the denial of vehicle registration without due cause. One facet of the consumer protection program is the exemption of certain classes of vehicles, for example, new cars and antique vehicles. An important aspect of the consumer protection program is a ceiling on the cost of repairs required for compliance. The ceiling could be either a flat rate or a percentage of the retail book value of the vehicle. This would eliminate the potential for certain vehicle owners experiencing undue hardships.

A consumer affairs office should be established to handle consumer complaints concerning overcharging and unnecessary repairs by garages as well as complaints about the program in general. This office could also be responsible for the licensing of repair facilities. If too many complaints about any one repair facility are received the consumer affairs office could investigate and revoke the license of the garage if the claims were justified.

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SECTION IV

ANALYSIS OF SELECTED ALTERNATIVES

The costs of the five alternative inspection/maintenance programs are presented in this section. The programs discussed are the following:

- Idle mode test conducted at state inspection station
- Idle mode test conducted at inspection station operated by a contractor to the state
- Idle mode test conducted at privately-owned service station and garages
- Loaded mode test conducted at state inspection station
- Loaded mode test conducted at inspection station operated by a contractor to the state

These were chosen in consultation with EPA and the air pollution control agencies of St. Louis City and County. As discussed in Section III of this report, mandatory maintenance was reviewed and considered unworthy of further investigation. The five alternatives analyzed thus constitute the universe of recognized types of inspection/maintenance programs. (Because of the high cost of a dynamometer and its space requirements loaded mode testing is considered to be beyond the scope of most private service stations and garages.)

The remainder of this section presents the assumptions, methodology, and results of our analysis of the alternatives mentioned. The reader who wishes to review the detailed calculations performed is referred to Appendices A and B of this report.

ASSUMPTIONS

In order to estimate the costs of the alternate programs, certain assumptions were made concerning the various parameters involved. All of these assumptions influence the determination of the number of test lanes needed for an inspection/maintenance program.

1. The emissions testing in Missouri is limited to St. Louis county and the city of St. Louis.
2. Only light-duty vehicles (8,500 lb or under) will be tested for emissions.
3. The number of light-duty vehicles grows at an annual rate of 4 percent. Therefore, in 1980 when the program is assumed to start, the light-duty vehicle population is estimated to be 920,000.
4. Emission testing will be conducted in conjunction with the existing safety testing procedures.
5. Thirty-three percent of the vehicles tested will require some repair. It is further assumed that with state or contractor-run systems, one-half of these vehicles will be retested at private service stations and garages and the other half will return to the state or contractor-run lane for the retest.
6. The combined safety and emissions test will require 25 minutes for each vehicle tested at a private service station or garage.
7. An idle mode test and safety inspection conducted at either a state run or contractor operated lane will require 12 minutes.
8. A loaded mode test and safety inspection at either a state run or contractor operated lane will require 14 minutes.

Based upon the above assumptions, an idle mode test conducted by either the state or a contractor would require 33 lanes to service St. Louis city and county. The number of lanes required for a loaded mode test is 44. Given the distribution of the population in St. Louis city and county, these lanes would be located as shown in Figures 3 and 4. Further, there will be inspection facilities which have either 1, 2, 3, or 4 lanes. Table 11 presents the distribution of the size of the testing facilities.

Table 11. DISTRIBUTION OF TEST LANES BY FACILITY SIZE

	Idle mode	Loaded mode
	Number	
1-lane station	1	-
2-lane station	1	3
3-lane station	2	2
4-lane station	6	8
Total number of stations	10	13
Total number of lanes	33	44

The number of private service stations and garages licensed to perform inspection affects the amount of time each station must spend on inspection. For this reason, three cases have been analyzed with each having a different number of licensees. The first case is the licensing of 1500 stations, which is approximating all the service stations, repair facilities, and automobile dealers in St. Louis city and county. The number of stations currently performing safety inspection in the area is 500, which has been chosen for the second case. The midpoint of 1000 is the third case. Table 12 illustrates the effect of the number of stations on the individual facility's inspection load. (The calculations for Table 11 are contained in Appendix A.)

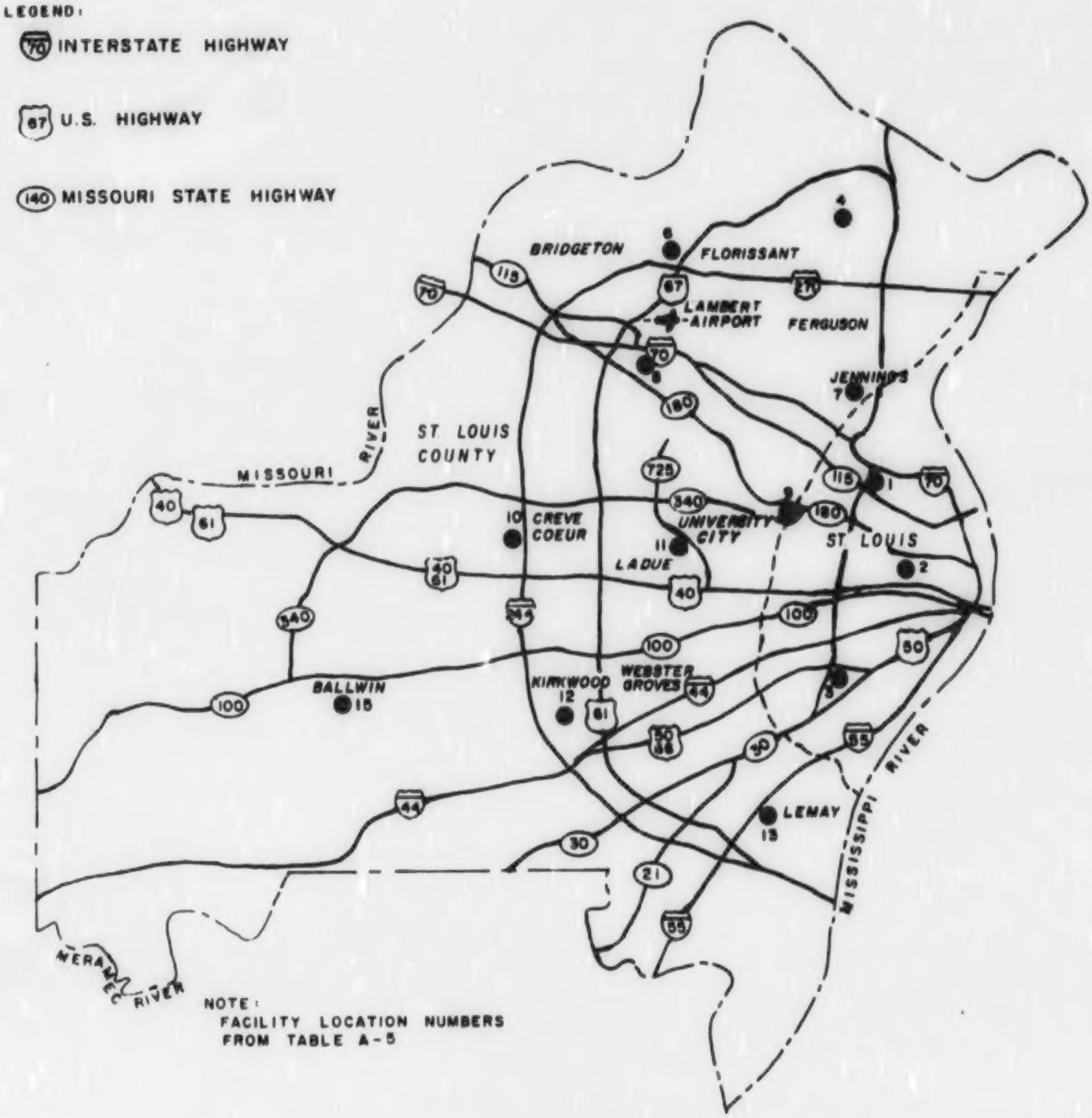
LEGEND:
70 INTERSTATE HIGHWAY
67 U.S. HIGHWAY
140 MISSOURI STATE HIGHWAY
BRIDGETON
FLORISSANT
LAMBERT AIRPORT
FERGUSON
JENNINGS
ST LOUIS COUNTY
MISSOURI RIVER
CREVE COEUR
UNIVERSITY CITY
LADUE
ST. LOUIS
BALLWIN
KIRKWOOD
WEBSTER GROVES
LEMAY
MISSISSIPPI RIVER
MERAMEC RIVER
1
2
3
4
5
6
7
9
10
11
12
13
15
70
115
67
270
180
725
340
40
61
244
100
44
50
30
21
55
NOTE:
FACILITY LOCATION NUMBERS FROM TABLE A-5

Figure 3. Location of loaded mode inspection facilities

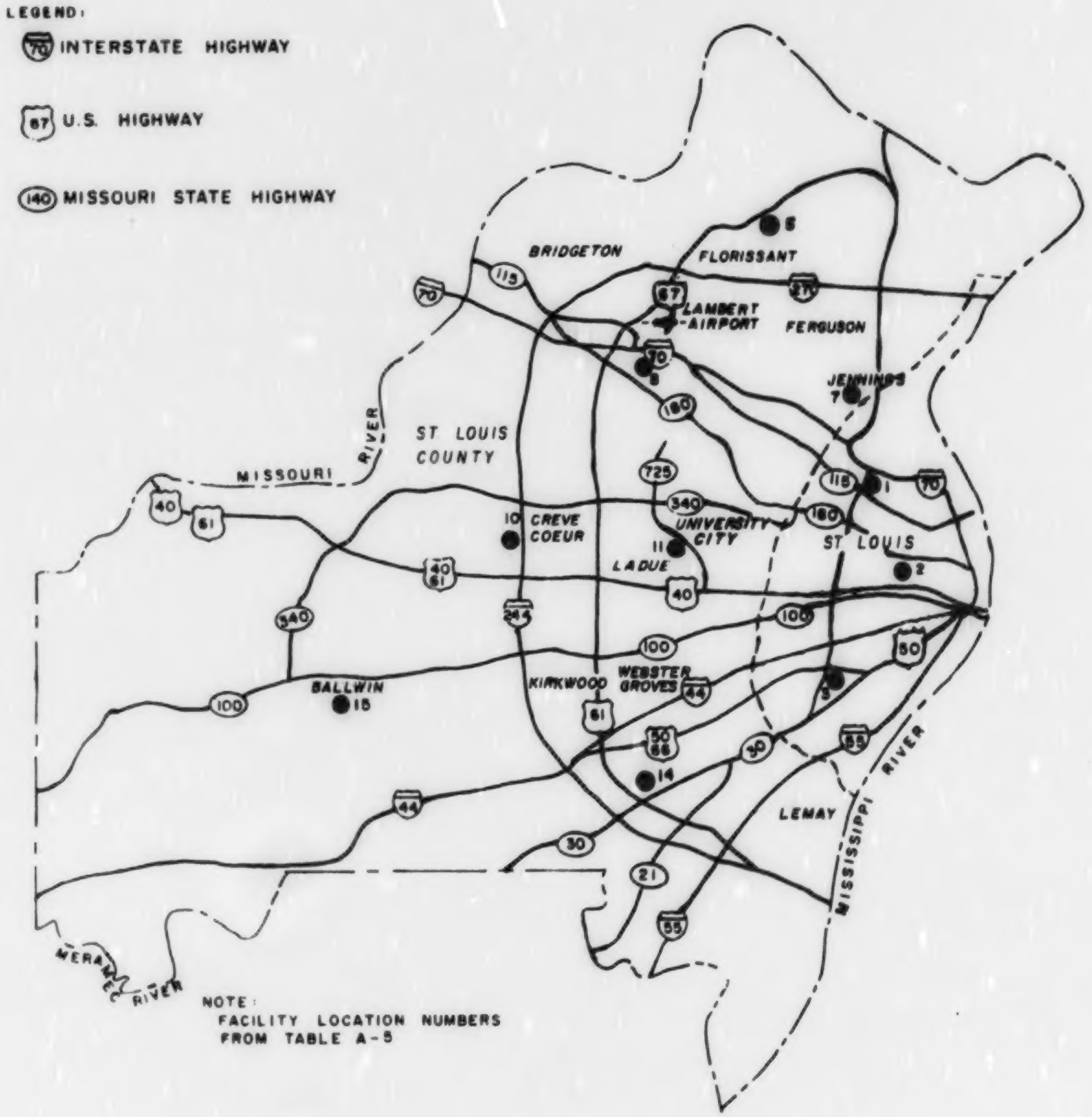
LEGEND:
70 INTERSTATE HIGHWAY
67 U.S. HIGHWAY
140 MISSOURI STATE HIGHWAY
BRIDGETON
FLORISSANT
LAMBERT AIRPORT
FERGUSON
JENNINGS
ST LOUIS COUNTY
MISSOURI RIVER
CREVE COEUR
UNIVERSITY CITY
LADUE
ST LOUIS
BALLWIN
KIRKWOOD
WEBSTER GROVES
LEMAY
MISSISSIPPI RIVER
MERAMEC RIVER
NOTE:
FACILITY LOCATION NUMBERS FROM TABLE A-5

Figure 4. Location of idle mode inspection facilities

Table 12. PER-STATION INSPECTION LOAD

	Number of stations licensed		
	1500	1000	500
Inspections per year	710	1060	2120
Hours per year	300	450	900
Average hours per day	1	1.5	3

METHODOLOGY

The costs involved in an I/M program are comprised of two categories of expenditures: capital costs are the initial outlays for the establishment of the program and operating costs are those attributed to the actual operation of the system. Operating costs plus the amortization of the capital cost are referred to as annual costs. The costs are further divided into per-station costs, program costs, and state costs. As the name implies, per-station costs are the capital and operating costs for an individual inspection facility. Program costs are the disbursements associated with the overall program, such as public relations. In addition to these costs, and regardless of who is operating the program, the state has administrative costs.

Cost Components

Station Costs - The capital costs for a station include all the items for establishing and equipping an inspection facility:

- land
- building
- equipment
- miscellaneous furniture

Operating costs are comprised of the day-to-day expenses:

- personnel salaries including overhead
- utilities and supplies
- equipment repair and replacement.

Program Costs - Program capital costs represent programs initiated before inspection has begun and items necessary to establish the stations. Included are:

- program design
- site acquisition
- public relations
- inspection training.

Site acquisition costs refer to the hours spent locating the lots, appraising their value, and negotiating their price. The costs of the initial stages of public relations program — a media campaign to inform the public about the program, informational seminars for repair establishment management, and the organization of a consumer affairs office, for example — are included in the capital costs. The training costs represent the organization of the training programs and the major effort before the operation of the program to prepare all inspectors.

Program annual costs are comprised of:

- data handling
- public relations
- annualized capital cost and interest of the inspection network.

Data handling is the record-keeping of the model, year, make and emission rates of all the vehicles inspection. In a central test lane alternative this can be done by means of a computerized system. In a privately run system the data must be collected by hand, which involves a larger staff on the part of the state. Annualized capital costs and interest represent loan repayment costs. Public relations annual expenditure are for the continuing facets of the program, including such items as brochures to vehicle owners and repair industry interface.

State Administrative Costs - For any of the alternatives the state's administrative costs include the salaries of personnel performing the following functions:

- enforcement
- consumer protection
- program evaluation
- program director
- clerical support
- mechanic training
- garage licensing.

Of these, mechanic training is a capital cost, since a large portion of the mechanics must be trained in advance of program operation.

The state has additional responsibilities in a privately-run system which include extensive data handling activities, public relations, and surveillance. The surveillance functions are to oversee repair facility performance and to calibrate the garages' emissions analyzers.

Data Sources

The specific sources of cost information are referenced in Appendix B. These include information obtained from equipment manufacturers, agencies in the State of Missouri, and data available from states which conduct an inspection/maintenance program. All costs are presented in 1976 dollars.

Computations

The steps involved in calculating the costs associated with inspection/ maintenance program are as follows.

1. Determine the per station capital cost — this is the summation of the various components of the initial outlays of a testing facility. Capital costs were determined for a private station and for state and contractor run stations with 1, 2, 3, and 4 testing lanes per station.

2. Determine the per station operating cost — this is the summarization of the recurring expenses associated with the operation of a testing facility. Operating costs were determined for a private station and for state and contractor run stations with 1, 2, 3, and 4 testing lanes per station.

3. Determine the total capital costs for each alternative network of inspection/maintenance facilities — this is derived by multiplying the number of facilities by the capital cost per facility. For an idle mode program run by the state or a contractor, the number of 1, 2, 3, and 4 lane facilities required (see Table 11) were multiplied by the capital cost associated with each and the results summed. The same procedure was followed for the loaded mode alternatives. For the privately-run system, the capital cost per facility was multiplied by the three alternatives discussed previously in this section.

4. Determine the total operating costs for each alternative network of inspection/maintenance facilities — this is derived by multiplying the number of facilities by the operating cost per facility. The procedure is the same as discussed in the determination of the network operating costs.

5. Amortize the capital costs for each network of inspection/maintenance facilities — it was assumed that the total capital costs would be financed through borrowing at an 8.5 percent rate of interest and the loan would be repayed in 10 years. Using the equation specified in Appendix B, the annual payment was determined. This is included as part of the program costs. This is applicable only to the state or contractor run systems.

6. Determine the capital expenditures of the program costs associated with a state or contractor run program. This is the summation of the initial outlays necessary for establishing the program.

7. Determine the annual program costs associated with a state or contractor run program — this is the sum of three items. There are the recurring costs of public relations and data handling, and the annualized program capital costs. The annualized program capital costs represent the amortization of the capital costs for each network of lanes (explained in step 5) and the amortization of the program capital costs (items included in step 6).

8. Determine the annual state administrative costs associated with each program. For a state or contractor run program, this is primarily the sum of the salaries paid to the staff administering the program. The administrative costs for a privately run program include salaries for a larger staff as well as amortized capital expenditures arising from such things as the purchase of equipment.

9. Determine the total annual cost associated with each alternative program. This is the sum of the total operating cost for each alternative network of lanes (step 4), the total annual program costs (step 7), and the annual state administrative costs (step 8).

10. Determine the inspection fee — this is the total annual costs (step 9) divided by the vehicle population tested.

RESULTS OF THE ANALYSIS

Table 13 presents the estimated inspection fee for each alternative. Analyzed for three cases of number of stations licensed, the privately-run system's inspection fee is based on a station's annual cost divided by the number of vehicles inspected per station. To this the state's administrative cost per vehicle is added, yielding an inspection fee ranging from $6.10 to $7.30.

For the state-run and contractor-run inspection fees, the idle mode inspection fee ranges from $3.90 for the state-run system to $4.60 for the contractor run system. For the loaded mode alternatives the fee is $5.25 for the state-run and $6.25 for the contractor run.

A discussion of the costs used to determine these fees follows.

Table 13. ESTIMATED INSPECTION FEES

Type of system	Annual cost/ vehicle, $	Administrative cost/ vehicle, $	Profit/vehicle, $	Estimated inspection fee, $
Privately-run				
1500 stations	6.70[a]	0.60	-	7.30
1000 stations	5.90	0.55	-	6.45
500 stations	5.60	0.50	-	6.10
State-run				
Idle mode	3.75	0.15		3.90
Loaded mode	5.10	0.15		5.25
Contractor-run				
Idle mode	3.70	0.15	0.75[a]	4.60
Loaded mode	5.10	0.15	1.00	6.25

[a] Assumes 15 percent return on instrument before taxes.

Private Stations

The various costs associated with a network of inspection lanes at private service stations and garages are presented in Tables 14 and 15. As shown in Table 14, the capital cost for a service station or garage is approximately $2500. This is the purchase price of an emission analyzer. The operating costs vary depending on the number of stations in the network and are composed of the labor rate (including overhead) and maintenance of the equipment.

Table 15 shows that the administrative costs to the state will range from $447,000 to $534,000 per year. This is to cover not only the administration of the program but also surveillance, public relations, and mechanics' training programs.

Table 14. CAPITAL AND ANNUAL COSTS ASSOCIATED WITH A PRIVATE GARAGE

	Number of stations licensed		
	1,500	1,000	500
Capital costs/stations	$2,500	$2,500	$ 2,500
Annual costs/station	4,100	5,400	10,300

Table 15. ADMINISTRATIVE COSTS OF A PRIVATELY-RUN SYSTEM

	Number of stations		
	1,500	1,000	500
Capital costs	$200,000	$176,000	$152,000
Annual costs	534,000	500,000	447,000

State or Contractor Run Test Lanes

Table 16 presents the capital and operating costs associated with either a state-run or contractor-run test facility for both an idle mode and a loaded mode test.

Table 16. CAPITAL AND OPERATING COSTS ASSOCIATED WITH CENTRAL TEST STATIONS

Test type	One-lane station	Two-lane station	Three-lane station	Four-lane station
Idle				
Capital costs	$153,000	$285,000	$398,000	$500,000
Operating costs	91,000	172,000	228,000	325,000
Loaded				
Capital costs	163,000	306,000	418,000	520,000
Operating costs	93,000	176,000	234,000	333,000

Program Costs - The cost differences between state-run and contractor-run systems occur in the overall program costs. The two areas in which they will differ are in site acquisition and program design costs. The site acquisition costs will be lower for the contractor since the State of Missouri requires at least two and usually three appraisals of property before a purchase. Only the labor involved in locating and procuring the sites will be included in the contractor's cost. Program design costs will be incurred by the state if it hires a firm to assist in the program specification and planning stages. These costs are broken out for the state. Because of certain design economies, program design costs are assumed to be less for a contractor and included in the total program costs.

The state has more options available for financing a project than does a private contractor. The following are among the state's alternaties.*

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*The first three options are mentioned as possibilities by a representative of the Missouri State Office of Administration. The last is currently proposed for the California program.

- Capital costs can be financed through general revenue funds either by an allocation or a loan against anticipated fees.
- Revenue sharing funds could be used to fund the project.
- The state could finance the capital costs through a bond issue.
- The program could be financed by a loan from another state agency or special fund, to be repaid within a specific interval with or without interest.

Table 17 presents this information.

Table 17. PROGRAM COSTS ASSOCIATED WITH THE CENTRAL TEST LANES

	Capital	Annual
Program costs		
State-run		
Idle mode	$360,000	$ 777,000
Loaded mode	378,000	1,036,000
Contractor-run		
Idle mode	158,000	746,000
Loaded mode	176,000	1,005,000

State Costs - Regardless of who operates the program the state will have mechanic training and administrative costs. The mechanic training program would be conducted before any inspection begins and would cost approximately $16,000 to train 4,000 mechanics. (This number represents one-third of the total number of people employed in service stations, repair garages and automobile dealers in the St. Louis area in 1973.) The cost is comprised of the instructor's salary and course materials.

Administrative functions include:

- program direction
- program evaluation
- mechanic certification

- repair facility licensing
- consumer protection
- repair industry surveillance

The administrative costs are the salaries of the personnel conducting these activities and represent about $0.15 per vehicle.

Table 18 presents the total cost of a network of state and contractor run test lanes for each type of emissions test.

Table 18. TOTAL SYSTEM COSTS FOR STATE AND CONTRACTOR RUN TEST LANES

	Capital	Annual
State-run idle mode (33 lanes)	$4,595,000	$3,448,000
State-run loaded mode (44 lanes)	6,921,000	4,698,000
Contractor-run idle mode (33 lanes)	4,393,000	3,417,000
Contractor-run loaded mode (44 lanes)	6,089,000	4,667,000

Costs to Private Garages for Reinspection

Under the retest option described in the assumptions, private garages would be licensed to perform reinspection. Each licensed garage would be required to purchase an emissions analyzer which would cost approximately $2,200. It is recommended that the fee a garage is allowed to collect for reinspection be in the $2.00 to $4.00 range. This figure is less than the fee charged for the initial inspection since less time is needed to "check" the repair work with an emissions analyzer than to perform the initial emissions inspection.

SUMMARY

This section has presented the cost considerations for all the program alternatives. The costs of the privately-run system are shared by the individual stations and the state. The station annual cost per vehicle inspected ranges from $5.60 to $6.70 depending on the number of stations licensed and the wage rate used; the state's annual cost per vehicle ranges from $0.53 to $0.63.

The station costs do not differ for the state-run and contractor-run systems. Some variations does occur in the program costs and in the inspection fee, to which a profit is added for the contractor-run system. The state's administrative cost is $0.15 per vehicle for either system.

In addition to cost considerations, each alternative must be weighed in terms of the quality control potential, consumer convenience, and fiscal and managerial responsibilities each represent. The intent of this section was to present as much information as possible without recommending one alternative over another.

Care should be taken in interpreting the cost information. While efforts were made to make the costs applicable to the St. Louis area this was not possible for every facet of the information. The costs should be construed as good estimates but by no means exact.

SECTION V

BENEFITS OF AN INSPECTION/MAINTENANCE PROGRAM

This section discusses the anticipated benefits from the implementation of an inspection/maintenance program in the St. Louis Air Quality Control Region. The most important benefit is, of course, a reduction in the level of carbon monoxide and hydrocarbon emissions. This is the intended objective of an inspection/maintenance program and is thus the focal point of this section. There are, however, secondary benefits resulting from inspection/maintenance and these are mentioned first.

INDIRECT BENEFITS OF AN INSPECTION/MAINTENANCE PROGRAM

The generally higher level of vehicle maintenance fostered by an inspection/maintenance program can result in improved performance, longer useful vehicle life, and an expected improvement in fuel economy. The first two of these benefits, improved performance and longer vehicle life are intuitively obvious. A well-maintained vehicle will operate better and longer. Of course, the quantification of this is speculative at best and beyond the scope of this study.

There is some data available, however, on the fuel savings potential of an inspection/maintenance program. This is presented in Table 19. As shown by the table, the more vehicles serviced, the greater the overall fuel savings. In most situations the annual dollar savings in money spent on gasoline can offset the cost of the inspection as well as the minor types of repair costs.

Table 19. FUEL SAVINGS FROM INSPECTION/MAINTENANCE PROGRAMS

Percentage of vehicles requiring repair	Annual fuel savings - serviced vehicles only		Savings per serviced vehicle, $	Annual fuel savings - all vehicles		Savings per vehicle - all vehicles, $
	Percent	Gallons		Percent	Gallons	
50	4.2	36	21.40	2.1	18	10.70
40	4.73	40	24.00	1.89	16	9.60
30	5.5	47	28.00	1.65	14	8.40
20	6.76	57	34.40	1.35	11	6.85
10	9.66	82	49.30	0.97	8	4.90

EMISSIONS REDUCTIONS IN THE ST. LOUIS AIR QUALITY CONTROL REGION

It is possible to evaluate the effect of an I/M program independent of actual emission quantities, and in particular independent of the emissions from those sources not affected by the program. However, it does provide a better perspective to consider the emissions reductions provided by the program in the context of the overall emissions picture in the St. Louis area. Accordingly, this study has made provision for estimation of emissions from the sources not subject to an I/M program, as well as from the light-duty vehicles that are the primary focus of the study. Table 20 summarizes estimated 1975 emissions from the various source categories, broken down by geographical area. It is apparent that the predominant portion of the emissions come from the urban core of the AQCR — St. Louis City and County, and Madison and St. Clair Counties in Illinois. It is also seen from Table 20 that motor vehicles contribute the major share of emissions; light-duty vehicles in particular contribute 85 percent of the CO and 63 percent of the hydrocarbons.

A detailed inventory was not within the scope of this study; Table 20 is based on a relatively approximate inventory, using existing data updated where desirable and possible. The following sections summarize the emissions and traffic data used, and then consider the anticipated effect of the I/M program on projected future emissions.

ESTIMATION OF EMISSIONS FROM LIGHT-DUTY VEHICLES

The proposed I/M program affects light-duty vehicles of two types, passenger cars and light-duty trucks. The latter group is defined as being under 8,500 pounds gross weight and includes those vehicles commonly known as pickup trucks and vans. Exhaust from light-duty vehicles is a major source of carbon monoxide and hydrocarbons. In addition, emissions of hydrocarbons occur from the crankcase (crankcase emissions) and from the fuel system (evaporative emissions).

Table 20. SUMMARY OF EMISSIONS ESTIMATED FOR 1975 (THOUSANDS OF TONS PER YEAR)

	Stationary sources	Heavy-duty trucks		Evaporative emissions	Light-duty vehicle exhaust emissions						Grand total		
					Without I/M program			With I/M program					
		Diesel	Gasoline		Autos.	LD trucks	Total	Autos.	LD trucks	Total	No I/M	Mo. I/M	Both I/M
Carbon monoxide													
St. Louis City and County	0	38.8	71.0	0	525.4	142.6	668.0				777.8		
Balance of Mo. portion[a]	0	8.2	14.9	0	110.1	29.9	140.0				163.1		
Missouri subtotal	0	47.0	85.9	0	635.5	172.5	808.0		(I/M program not in effect in 1975)		940.9		
Madison and St. Clair Counties	0	16.9	30.9	0	169.7	46.0	215.7				263.5		
Balance of Ill. portion[b]	0	3.5	6.4	0	35.4	9.6	45.0				54.9		
Illinois subtotal	0	20.4	37.3	0	205.1	55.6	260.7				318.4		
Total AQCR	0	67.4	123.2	0	840.6	228.1	1068.7				1259.3		
Hydrocarbons													
St. Louis City and County	30.2	6.2	8.4	18.9	46.8	14.8	61.6				125.3		
Balance of Mo. portion	1.0	1.3	1.8	3.6	9.8	3.1	12.9				20.6		
Missouri subtotal	31.2	7.5	10.2	22.5	56.6	17.9	74.5				145.9		
Madison and St. Clair Counties	19.5	2.7	3.7	6.8	15.2	4.7	19.9				52.6		
Balance of Ill. portion	0.3	0.6	0.8	1.4	3.1	1.0	4.1				7.2		
Illinois subtotal	19.8	3.3	4.5	8.2	18.3	5.7	24.0				59.8		
Total AQCR	51.0	10.8	14.7	30.7	74.9	23.6	98.5				205.7		

[a] Franklin, Jefferson, and St. Charles counties.

[b] Bond, Clinton, Monroe, Randolph, and Washington counties.

[c] Since the preparation of these tables, more current data on stationary source emission in the Illinois portion of the AQCR have been tabulated by the Illinois Environmental Protection Agency. They are as follows:

	Carbon Monoxide, thousands of tons/year	Hydrocarbon, thousands of tons/year
Madison and St. Clair counties	23.8	61.0
Balance of Illinois portion	2.5	1.3
Illinois subtotal	26.3	62.3

Exhaust Emissions

The major share of the emissions from motor vehicles is from the exhaust, and is a function of parameters and conditions in the engine. It is in reducing these emissions that an I/M program has its effect. Estimates of exhaust emissions both with and without a program have been made for calendar years 1975, 1980, 1985, and 1990, using EPA's most current published estimation procedure.[1]

The standard EPA emission estimation methodology, as published in Reference 2, is based on the use of a composite emission factor derived from mean emission factors determined according to the Federal Test Procedure, with adjustments to account for other factors. The algorithm was implemented in a brief computer program, which is included in Appendix C. The following paragraphs define the several factors involved, indicating their implementation in the St. Louis situation.

FTP Emission Factor - These emission factors are the basic part of the equation, providing the emissions in grams per mile for each model year vehicle in each calendar year. For calendar years 1971 and 1972 they represent the result of actual emissions tests (based on 1975 Federal Test Procedure); for subsequent years they are projections based on presently available (as of 12/75) emission tests and deterioration studies. The emission factors are presented in three groups — for high-altitude areas, for California, and for low-altitude areas outside California. The latter were used for St. Louis.

Fraction of Annual Travel - This factor expresses the proportions of the total vehicle miles of travel (VMT) in an area that are performed by cars of various model years during various calendar years. If the distribution is assumed not to change over time (a standard assumption), then this becomes a weighted distribution of annual travel by vehicle age. As such it incorporates both the age distribution in the vehicle population and the differences in usage of vehicles of different ages. This is the only factor (aside from the mean emission factors) that differs between automobiles and light-duty trucks.

The factors used in the present study, for both automobiles and light-duty trucks, are based on a composite local age distribution specific to the St. Louis area, as in Table 21, and the national usage distribution presented in Reference 1.

Table 21. VEHICLE AGE DISTRIBUTION IN ST. LOUIS CITY AND COUNTY

Model year	Age[a]	Number of vehicles[b]	Proportion
1975	0	36,118	0.052
1974	1	76,279	0.110
1973	2	90,755	0.131
1972	3	78,570	0.114
1971	4	63,499	0.092
1970	5	60,370	0.087
1969	6	63,344	0.091
1968	7	52,743	0.076
1967	8	40,422	0.059
1966	9	39,797	0.058
1965	10	33,037	0.048
1964	11	21,865	0.032
1963	12	14,385	0.021
pre-1963	≥13	20,140	0.029

[a] As of July 1, 1975.

[b] Source: R. L. Polk Co.

Speed Correction Factor - The Federal Test Procedure implicitly involves an average route speed of 19.6 miles per hour (31.6 km/hr). A speed correction factor can be used to adjust the emissions estimates to account for different average route speeds. This would be appropriate, for instance, if emissions were being estimated separately for open rural areas and congested center city areas. Since the desired estimates in St. Louis are integrated over large areas, the precise situation to which the integrated FTP driving cycle is meant to apply, no adjustment is required, and this factor was not utilized.

Temperature Correction Factor - The Federal Test Procedure specifies a temperature range (68 to 86°F), and hence the FTP emission factors implicitly assume an average ambient temperature of 75°F. The temperature correction factor is used to adjust the emissions estimates to account for a differing ambient temperature. The correction is expressed as linear functions of the ambient temperature that equal unity at 75°F. These are:

- for CO, 1.95 - 0.0127(TEMP)
- for HC, 1.81 - 0.0113(TEMP)
- for NO_x, 1.36 - 0.0046(TEMP)

Since the average annual temperature in St. Louis (climatological normal at Lambert Field) is about 55°F, the estimates were adjusted to that value.

Hot/Cold Vehicle Operation Correction Factor - The Federal Test Procedure, and hence the Reference 2 methodology, implicitly assumes a specific mix of engine operation in the three operating categories "cold" condition, "hot start-up" condition, and "hot stabilized" condition (the latter two are considered identical for noncatalyst-equipped; i.e., pre-1975 vehicles). The correction factor permits adjusting the emissions estimates to account for a different mix of conditions. This would be appropriate, for instance, if estimates were desired for specific times of day or specific small portions of an urban area.

Since the estimates being made for St. Louis are integrated over large areas, it was considered inappropriate to utilize this refinement. Consequently, the correction factor was defined as unity for the present study.

The aggregate data on vehicle miles of travel (VMT), to which the composite emission factors are applied, were provided by the respective state highway departments. This VMT data was for 1975, and was projected at the rate of 4 percent per year. This is the same growth rate established for vehicle population, so that there is an implicit assumption that the vehicle usage patterns will not change. The VMT data as actually used for the emissions estimates is tabulated in Table 22. It is of course noted that there is a major increase in the VMT over the years.

Crankcase and Evaporative HC Emissions

The crankcase and evaporative emissions are not specifically reduced by an I/M program. Rather, the estimation methodology assumes that the program is necessary to prevent significant removal or disabling of these devices and hence to maintain the anticipated emission factor for the entire vehicle population. The HC emissions from these sources are calculated on the basis of the number of vehicles, rather than by the VMT. This is EPA recommended policy. Sample calculations are tabulated in Table 23.

EMISSIONS FROM OTHER SOURCES

Several source categories other than the light-duty gasoline vehicles with which I/M is concerned can also cause significant emissions of one or more of the major pollutants. These include heavy-duty trucks, both gasoline and diesel, and stationary sources. Emissions from the heavy-duty vehicles were calculated using the standard techniques and emission factors in Reference 1. The 1975 stationary point source HC emissions were provided by the EPA project officer, and gasoline marketing emissions were calculated using Reference 2.

Table 22. ESTIMATES OF VMT BY LIGHT-DUTY VEHICLES AS USED TO ESTIMATE EMISSIONS (VMT in trillions)

	1975	1980	1985	1990
St. Louis City and County	8.30	10.10	12.29	14.95
Three other Mo. counties	1.74	2.11	2.57	3.13
Missouri portion	10.04	12.21	14.86	18.08
Madison and St. Clair counties	2.68	3.26	3.97	4.83
Five other Ill. counties	0.56	0.68	0.82	1.00
Illinois portion	3.24	3.94	4.79	5.83
AQCR total	13.28	16.15	19.65	23.91

Table 23. CRANKCASE AND EVAPORATIVE HYDROCARBON EMISSIONS

	1975	1980	1985	1990
Percent cars by age				
pre-1971 cars	49.7	13.0	–	–
1971 cars	9.2	5.8	–	–
1972-90 cars	40.2	81.2	100.0	100.0
Composite emission factor				
(g/day/car)	62.6	54.7	51.7	51.7
Number of vehicles (1000's)				
St. Louis City and County	750	913	1,110	1,350
Total AQCR	1,220	1,480	1,800	2,200
Emission (10^6 g/day)				
St. Louis City and County	46.95		57.39	69.80
Total AQCR	76.37	80.96	93.06	113.7
Emissions (tons/year)				
St. Louis City and County	18,800	20,100	23,000	28,000
Total AQCR	30,700	32,500	37,400	45,700

Emission Projections

Projections of emission rates into the future were based on the anticipated turn-over of vehicles and the published EPA emission factors, which are based on new-car emission factors as presently applicable. It is worthwhile to note that EPA has recommended changes in these standards, but they have not received congressional approval. Projections of stationary source emissions were made approximately, based on the present plans for stationary source hydrocarbon control in the St. Louis area. Summaries of the anticipated future emissions are tabulated in Tables 24 through 26. The predominant feature of the projections is the decrease in light duty vehicle exhaust emissions caused by the federal new car emission standards. program. Evaporative and heavy-duty vehicle emissions decrease initially as present standards are implemented, and then increase again as the growth in vehicular population catches up.

Effect of I/M Program

The effect of the I/M program is to reduce the exhaust emissions from the light-duty vehicles that are subject to the program. The estimate effectiveness data was taken from Appendix N - Emission Reductions Achievable Through Inspection and Maintenance of Light-Duty Vehicles, Motorcycles, and Light- and Heavy-Duty Trucks (40 CFR Part 51) (FR Vol 42 No. 84 pp. 22177-83). As seen in Tables 24 through 26, the reduction of exhaust emissions amounts to about 38 percent of the CO and 28 percent of the HC by 1985 to 1990. (The effectiveness increases over time because of an increasing percentage of catalyst-equipped cars, for which I/M is more effective.)

Because the share of total AQCR emissions contributed by light-duty vehicle exhaust is smaller in the case of hydrocarbons than for CO, the overall effect of the I/M program is less. Other categories of emission sources, such as heavy-duty vehicles and evaporative losses, are not currently projected to decrease as rapidly as light-duty exhaust emissions.

Table 24. SUMMARY OF EMISSIONS ESTIMATED FOR 1980 (THOUSANDS OF TONS PER YEAR)

	Stationary sources	Heavy duty trucks		Evaporative emissions	Light-duty vehicles exhaust emissions						Grand total		
					Without I/M program			With I/M program					
		Diesel	Gasoline		Autos.	LD trucks	Total	Autos.	LD trucks	Total	No I/M	Mo. I/M	Both I/M
Carbon Monoxide													
St. Louis City and County	0	47.2	71.8	0	330.1	133.3	463.4	259.7	101.5	361.2	582.4	480.2	480.2
Balance of Mo. portion[a]	0	10.0	15.3	0	69.0	27.8	96.8	69.0	27.8	96.8	122.1	122.1	122.1
Missouri subtotal	0	57.2	87.1	0	399.1	161.1	560.2	328.7	129.3	458.0	704.5	602.3	602.3
Madison and St. Clair Counties	0	20.6	31.3	0	106.5	43.0	149.5	83.8	32.8	116.6	201.4	201.4	168.5
Balance of Ill. portion[b]	0	4.2	6.5	0	22.2	9.0	31.2	22.2	9.0	31.2	41.9	41.9	41.9
Illinois subtotal	0	24.8	37.8	0	128.7	52.0	180.7	106.0	41.8	147.8	243.3	243.3	210.4
Total AQCR	0	82.0	124.9	0	527.8	213.1	740.9	434.7	171.1	605.8	947.8	845.6	812.7
Hydrocarbons													
St. Louis City and County	28.7	7.6	4.9	20.1	30.9	12.4	43.3	27.7	11.0	38.7	104.6	100.0	100.0
Balance of Mo. portion	1.1	1.5	1.1	3.7	6.5	2.6	9.1	6.5	2.6	9.1	16.5	16.5	16.5
Missouri subtotal	29.8	9.1	6.0	23.8	67.4	15.0	52.4	34.2	13.6	47.8	121.1	116.5	116.5
Madison and St. Clair Counties	18.0	3.3	2.2	7.2	10.0	4.0	14.0	8.9	3.6	12.5	44.7	44.7	43.2
Balance of Ill. portion	0.4	0.7	0.4	1.5	2.1	0.8	2.9	2.1	0.8	2.9	5.9	5.9	5.9
Illinois subtotal	18.4	4.0	2.6	8.7	12.1	4.8	16.9	11.0	4.4	15.4	50.6	50.6	49.1
Total AQCR	48.2	13.1	8.6	32.5	49.5	19.8	69.3	45.2	18.0	63.2	171.7	167.1	165.6

[a] Franklin, Jefferson, and St. Charles counties.

[b] Bond, Clinton, Monroe, Randolph, and Washington counties.

Table 25. SUMMARY OF EMISSIONS ESTIMATED FOR 1985 (THOUSANDS OF TONS PER YEAR)

	Stationary sources	Heavy duty trucks		Evaporative emissions	Light-duty vehicles exhaust emissions						Grand total		
					Without I/M program			With I/M program					
		Diesel	Gasoline		Autos.	LD trucks	Total	Autos.	LD trucks	Total	No I/M	Mo. I/M	Both I/M
Carbon monoxide													
St. Louis City and County	0	57.5	64.9	0	175.9	105.9	281.8	96.3	57.4	153.7	404.2	276.1	276.1
Balance of Mo. portion[a]	0	12.1	13.9	0	36.8	22.1	58.9	36.8	22.1	58.9	84.9	84.9	84.9
Missouri subtotal	0	69.6	78.8	0	212.7	128.0	340.7	133.1	79.5	212.6	489.1	361.0	361.0
Madison and St. Clair Counties	0	25.0	28.3	0	56.8	34.2	91.0	31.1	18.5	49.6	144.3	144.3	102.9
Balance of Ill. portion[b]	0	5.2	5.8	0	11.7	7.1	18.8	11.7	7.1	18.8	29.8	29.8	29.8
Illinois subtotal	0	30.2	34.1	0	68.5	41.3	109.8	42.8	25.6	68.4	174.1	174.1	132.7
Total AQCR	0	99.8	112.9	0	281.2	169.3	450.5	175.9	105.1	281.0	663.2	535.1	493.7
Hydrocarbons													
St. Louis City and County	16.1	9.2	4.5	23.0	15.8	9.1	24.9	10.4	6.0	16.4	77.7	69.2	69.2
Balance of Mo. portion	1.4	1.9	0.9	4.4	3.2	1.9	5.1	3.2	1.9	5.1	13.7	13.7	13.7
Missouri subtotal	17.5	11.1	5.4	27.4	19.0	11.0	30.0	13.6	7.9	21.5	91.4	82.9	82.9
Madison and St. Clair Counties	8.7	4.0	2.0	8.3	5.1	2.9	8.0	3.4	1.9	5.3	31.0	31.0	28.3
Balance of Ill. portion	0.5	0.9	0.4	1.7	1.1	0.6	1.7	1.1	0.6	1.7	5.2	5.2	5.2
Illinois subtotal	9.2	4.9	2.4	10.0	6.2	3.5	9.7	4.5	2.5	7.0	36.2	36.2	33.5
Total AQCR	26.7	16.0	7.8	37.4	25.2	14.5	39.7	18.1	10.4	28.5	127.6	119.1	116.4

[a] Franklin, Jefferson, and St. Charles counties.

[b] Bond, Clinton, Monroe, Randolph, and Washington counties.

Table 26. SUMMARY OF EMISSIONS ESTIMATED FOR 1990 (THOUSANDS OF TONS PER YEAR)

	Stationary sources	Heavy duty trucks		Evaporative emissions	Light-duty vehicle exhaust emissions[c]						Grand total		
					Without I/M program			With I/M program					
		Diesel	Gasoline		Autos.	LD trucks	Total	Autos.	LD trucks[c]	Total	No I/M	Mo. I/M	Both I/M
Carbon monoxide													
St. Louis City and County	0	69.9	72.8	0	139.9	115.3	255.2	62.3	51.3	113.6	397.9	256.3	256.3
Balance of Mo. portion[a]	0	14.5	15.6	0	29.3	24.2	53.5	29.3	24.2	53.5	83.6	83.6	83.6
Missouri subtotal	0	84.4	88.4	0	169.2	139.5	308.7	91.6	75.5	167.1	481.5	339.9	339.9
Madison and St. Clair Counties	0	30.3	31.8	0	45.2	37.3	82.5	20.1	16.6	36.7	144.6	144.6	98.8
Balance of Ill. portion[b]	0	6.3	6.6	0	9.4	7.7	17.1	9.4	7.7	17.1	30.0	30.0	30.0
Illinois subtotal	0	36.6	38.4	0	54.6	45.0	99.6	29.5	24.3	53.8	174.6	174.6	128.8
Total AQCR	0	121.0	126.8	0	223.8	184.5	408.3	121.1	99.8	220.9	656.1	514.5	468.7
Hydrocarbons													
St. Louis City and County	19.4	11.2	3.9	28.0	11.2	9.6	20.8	6.3	5.4	11.7	83.3	74.2	74.2
Balance of Mo. portion[a]	1.7	2.3	0.9	5.5	2.4	2.0	4.4	2.4	2.0	4.4	14.8	14.8	14.8
Missouri subtotal	21.1	13.5	4.8	33.5	13.6	11.6	25.2	8.7	7.4	16.1	98.1	89.0	89.0
Madison and St. Clair Counties	10.5	4.9	1.7	10.1	3.6	3.1	6.7	2.0	1.8	3.8	33.9	33.9	31.0
Balance of Ill. portion[b]	0.6	1.0	0.4	2.1	0.8	0.6	1.4	0.8	0.6	1.4	5.5	5.5	5.5
Illinois subtotal	11.1	5.9	2.1	12.2	4.4	3.7	8.1	2.8	2.4	5.2	39.4	39.4	36.5
Total AQCR	32.2	19.4	6.9	45.7	18.0	15.3	33.3	11.5	9.8	21.3	137.5	128.4	125.5

[a] Franklin, Jefferson, and St. Charles counties.

[b] Bond, Clinton, Monroe, Randolph, and Washington counties.

This is largely a matter of the historical priority with which they were attacked, rather than because they are intrinsically more difficult to control, and it is reasonable to presume that these other sources will subsequently be further controlled.

REFERENCES

1. Binder of Inspection/Maintenance Background Material. Prepared by U.S. Environmental Protection Agency. April 30, 1976.

2. Supplement No. 5 for Compilation of Air Pollutant Emission Factors, Second Edition. EPA Publication No. AP-42. U.S. Environmental Protection Agency. Research Triangle Park, N.C. December 1975.

SECTION VI

IMPLEMENTATION SCHEDULE

This chapter presents an implementation schedule for I/M in the St. Louis area. The steps necessary to implement the program are discussed, agency roles are identified, and the time required for implementation is estimated. The schedule shown in Figure 5 was developed from and based on a review and analysis of the I/M schedule proposed by the Missouri Air Conservation Commission.[1] It reflects the time needed to implement either a state- or contractor-run system. A timetable for a privately-run system is at the end of this section. The steps are aggregated into four stages of implementation as follows:

- Program review and legislation
- Program development
- Construction and implementation
- Operations

PROGRAM REVIEW AND LEGISLATION

The first state of implementation involves the development of legislation. This stage begins with an initial review of I/M and concludes with the adoption of the enabling legislation.

The time required for this stage is difficult to estimate accurately since the initial review conducted by some locales has consumed as much as 3 or more years. Approximately 1-1/4 years are required to produce legislation once the needs of an I/M program are firmly established. Time zero on the schedule is defined as that moment when the legislative process begins.

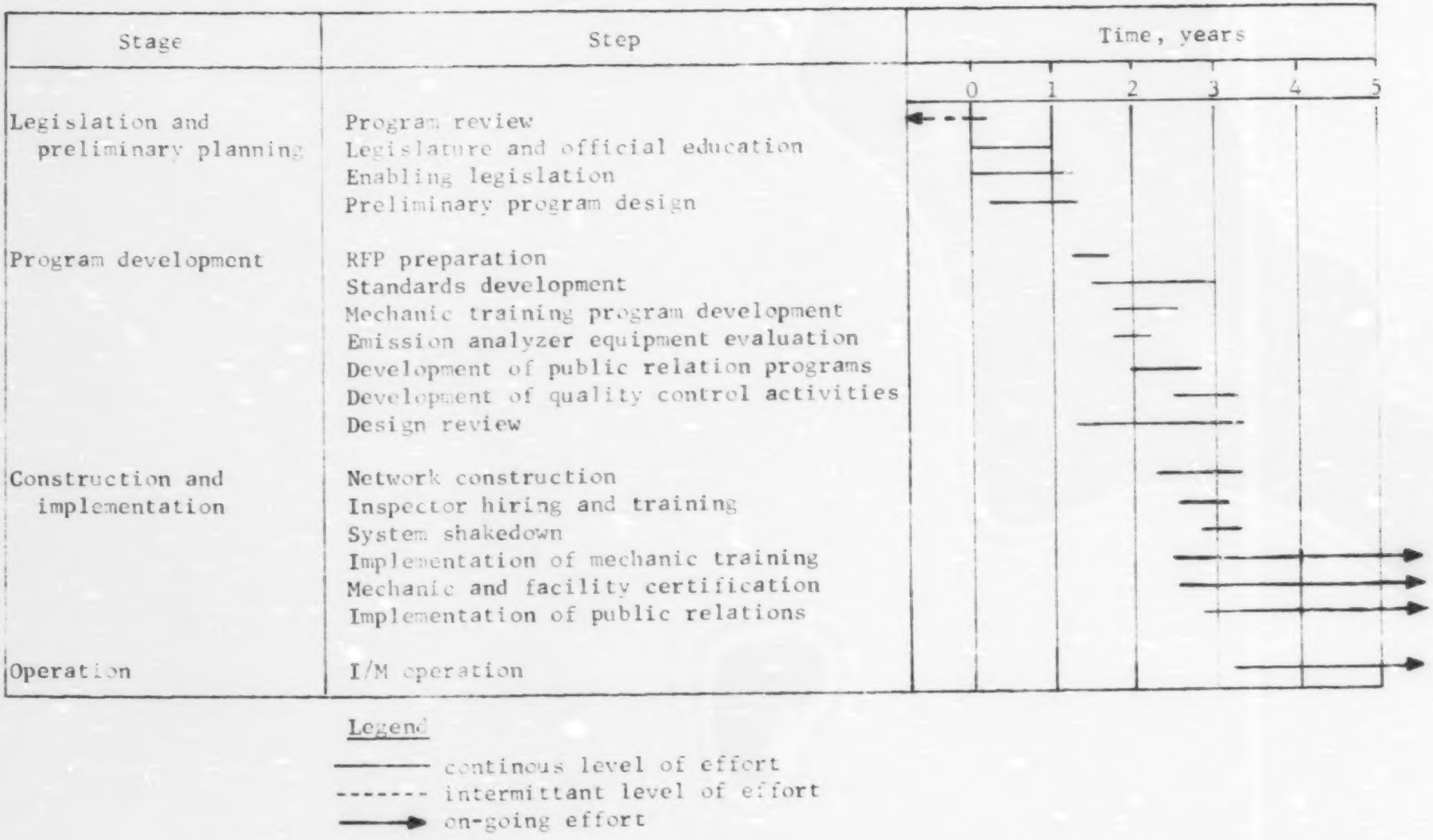


Figure 5. I/M implementation schedule for state or contractor run system

Program Review

Review of I/M for the St. Louis area has been initiated by the Missouri Air Conservation Commission (MACC) with technical support provided by the Division of Environmental Quality of the Missouri Department of Natural Resources (DNR). Other state and local agencies such as the St. Louis City and County Divisions of Air Pollution Control have also contributed to the review process.

The purpose of the initial program review is to identify the potential costs and benefits of an I/M program. After demonstration of the necessity of I/M, the next step is to inform the cognizant officials and the state legislature of what is involved with an I/M program. This step consists of providing the state legislature and key state agency officials with the finding of the preliminary I/M review. The information contained in this report serves this function.

Legislation and Preliminary Program Description

The drafting of the enabling legislation requires a preliminary description of the major program components. At a minimum, the type of text and the organizational option chosen must be decided upon prior to the drafting of the legislation. In addition, program objectives, operating rules, program dimensions, and major agency responsibilities should be specified. DNR should work closely with legislative committees to draft provisions for the legislation.

Information from other groups such as the Motor Vehicle Bureau of the Missouri Department of Revenue will be required to resolve specific issues affecting the operations of these groups. As an example, the current Motor Vehicle Statutes will require amendments to permit the combination of the proposed emission inspection with the present safety inspection.[2]

The product of these efforts is the initial legislation to authorize program development and operation. As the program development advances it is likely that other issues will surface which require legislative action. The result will be the revision or modification of the initial legislation. Both Arizona and New Jersey, two states with established inspection programs, have required changes to their original legislation.

PROGRAM DEVELOPMENT

After the state legislature passes the enabling legislation, the actual program development begins. One state agency or department will have the responsibility to coordinate the various program activities. It is estimated that 2 years will be required to complete the activities described below.

Program Development Activities

The lead state agency and cooperating state and local agencies should be able to carry out all of the activities of an I/M program, although assistance from the private sector may be needed to supplement existing agency resources. Identification of any outside assistance should come soon after the enabling legislation is passed to allow time for Request for Proposal (RFP) preparation and bid solicitation. A period of 6 months is allotted on the schedule for the time expended from RFP preparation to contract execution.

Emission standards must also be established during this stage of the implementation process. As discussed in Section III of this report, while this step could involve a collection of vehicle emission rates from a sample of vehicles, it would be advantageous to instead review the data and standards from states which have an inspection/maintenance program. A period of 1-1/4 years, the amount of time shown in Figure 5, would be needed to conduct a full-scale data collection and analysis effort. If existing data from other states is used, approximately 6 months would be needed.

The lead state agency would be responsible for the development of mechanic training, public relations and quality control programs. Each task requires about 9 months. Assistance in the development efforts may be required from other state agencies. For example, the New Jersey Department of Environmental Protection has worked with the Department of Education to investigate ways to train mechanics.[3] The New Jersey Office of Consumer Affairs became involved in investigating consumer complaints.[3]

Emissions analyzer equipment evaluations encompasses three tasks: development of performance criteria, testing and analysis of equipment performance, and certification of acceptable equipment. Equipment evaluation would be the responsibility of the lead agency for both centralized inspection lane and repair industry use. Evaluation requires about 6 months and would be tied into the vehicle testing aspects of standards development. Data on emission analyzers is available from states having an inspection/maintenance program.

Design Review

The purpose of the design review step is to provide the lead agency with the opportunity to coordinate the program development stage, to evaluate program progress and achievement, and to combine the final program components into a definitive operation. The program components include the previously mentioned activities and other functions such as the reexamination of the preliminary program design.

CONSTRUCTION AND IMPLEMENTATIONS

During this stage the programs developed in the previous stage are implemented and the construction of the inspection network begins. Construction, including land acquisition, requires about 1 year. The programs implemented at this time are scheduled to extend through the life of the inspection operation.

Network Construction

Construction of an I/M inspection network refers to either the actual construction of centralized inspection facilities or the establishment of a network of certified private garages. The lead agency's activities would vary with the organizational option selected but in either case approximately 1 year's time would be expended.

The hiring and training of personnel as inspectors for the centralized lane operations could begin as the first inspection lane is completed. Training mechanics as inspectors would be combined with the activities to train the mechanic in emission related repair procedures. A systems shakedown step would serve four purposes.

- On-the-job training of inspectors
- Voluntary testing for public familiarization
- Confirmation of emissions standards and evaluation of program design
- Attainment of program operation experience

The lead agency would supervise these activities. The full-scale operation is scheduled to start as soon as network construction is finished and the facilities are approved for operation.

Implementation

Three programs are implemented concurrently with the construction phase. Mechanic training and mechanic and repair facility certification are implemented at this time to permit the service industry to develop expertise in emissions maintenance and to allow time to certify an adequate number of private stations to perform repairs. Public relation activities are initiated to familiarize the public with the operations of an I/M program before the public is required to comply with the emission standards.

The lead agency would oversee the implementation of these programs. The effort would be extensive for approximately 1 year after which a continuous but less extensive level of effort will be required.

OPERATION

The last stage in the implementation of an I/M program is the initiation of the full-scale inspection operation. The operation is best phased in by gradually stiffening the emission standards. Associated with the inspection operation is the implementation and continuation of the quality control programs developed during the earlier stages to monitor program achievement. Approximately 2 years are required from adoption of the enabling legislation to initiation of the inspection operation.

INSPECTION AT PRIVATE SERVICE STATIONS AND GARAGES

The amount of time to establish an inspection/maintenance program using private facilities would involve less time to implement. Figure 6 presents a comparison of this alternative with the state or contractor option.

As shown by the figure, there is no need for RFP preparation, network construction, or a system shakedown under these options. This allows for the privately-run alternative to be established in approximately 1 to 1-1/2 years from the adoption of the enabling legislation.

Stage	Step	Time needed for private station alternative
Legislation and preliminary planning	Program review	Same
	Legislature and official education	Same
	Enabling legislation	Same
	Preliminary program design	Same
Program development	RFP preparation	No time needed
	Standards development	Same
	Mechanic training program development	Same
	Emission analyzer equipment evaluation	Same
	Development of public relation programs	Same
	Development of quality control activities	Same
	Design review	Same
Construction and implementation	Network construction	No time needed
	Inspector hiring and training	6 months
	System shakedown	No time needed
	Implementation of mechanic training	Same
	Mechanic and facility certification	Same
	Implementation of public relations	Same
Operation	I/M operation	Same

Figure 6. Time needed to implement a privately-run inspection/maintenance system as compared to a state or contractor system

REFERENCES

1. Missouri Air Conservation Commission. Proposed I/M Implementation Schedule.

2. Missouri Department of Revenue. State of Missouri Revised Statutes, Chapter 307 Vehicle Equipment Regulations. Jefferson City, Missouri. January 1975.

3. U.S. Environmental Protection Agency. Inspection and Maintenance: A Guide for Implementation Strategies and Air Standards Division. Research Triangle Park, North Carolina. February 25, 1974.

APPENDIX A

INSPECTION LANE NETWORK REQUIREMENTS

This appendix presents the assumptions, methodology, and calculations used to determine the size of the inspection lane network and the location of the inspection facilities. Each variable influencing the final program configuration is discussed in the order it enters into the calculations. The variables are the following:

- Inspection Lane Vehicle Throughput
- Annual Inspection Lane Capacity
- Annual Network Capacity
- Facility Siting and Lane Distribution

INSPECTION LANE VEHICLE THROUGHPUT

The purpose of this section is to compute the throughput of two distinct lane designs, one comprising a loaded emission test and the other comprising an idle emission test. Throughput refers to the rate at which vehicle tests are processed. The parameters which affect lane throughput are presented first.

Inspection Lane Design Variables

There are several design variables which affect the inspection process. The major factors are listed below:

- Type
- Scope

- Duration
- Sequence

Type of Inspection - Motor vehicles in the State of Missouri are currently required to undergo an annual safety inspection. The basis of this report is the supposition that those vehicles registered within St. Louis City and County will also be required to comply with exhaust emission standards. It is assumed that both safety and emissions testing will be conducted together.

Scope of Inspection - In the analyses of alternative test systems, it is assumed that the existing Missouri safety inspection is combined with either an idle mode or a loaded mode emissions test. Table A-1 is a listing of the inspection checklist for the Missouri safety inspection program. The scope of this program will be broadened to include emissions testing in St. Louis City and County.

Duration of Inspection - A third factor in the inspection process design is the duration of the test. The total time required to inspect a motor vehicle is correlated to some degree with the scope of the inspection. Total time expended on vehicle inspection, not including vehicle wait, ranges from a low of 4 to 6 minutes to a high of 20 to 30 minutes. Table A-2 provides the estimated duration of a number of varied program types across the country. Both Cincinnati and New Jersey have combined safety and idle mode emission inspection programs which require 4 to 6 minutes. The loaded mode emission inspection programs which are performed within an inspection lane require about 6 minutes. The Arizona Motor Vehicle Diagnostic Inspection Demonstration Project is designed to gather data on the cost and benefits of motor vehicle inspection and related repairs. Inspection time for this demonstration program averages about 25 to 30 minutes per vehicle. Arizona conducts an extensive inspection of nearly 200 safety and emission related items.

Table A-1. MISSOURI MOTOR VEHICLE SAFETY INSPECTION CHECKLIST

Inspection checklist		
Code	Equipment	Inspect for
A	Lighting equipment Headlights Taillights Beam indicator	Operation, mounting and lense condition
B	Signalling devices Turn signals Signal indicator Stop lights	Operation, mounting and lense condition
C	Horn	Operation and adequate signal
D	Windshield wipers	Operation and worn or damaged parts
E	Windshield and other glass	Vision and dangerous breakage
F	Mirrors	Mounting and condition
G	Seat belts (1965 and later pass. vehicles)	Two sets front seat
H	Steering mechanisms Steering wheel Front wheel Pitman arm Stabilizer link Tie rods Idler arm Ball joints King pins Control arms Springs Torsion bars Shackles Shock absorbers Power steering	Wheel alignment and worn, damage or disconnected parts List amount of play in defective ball joint
I	Exhaust system	Mounting and leakage
J	Tires and wheels	Mismatching or impairment
K	Brakes Hoses Master cylinder Wheel cylinder Drum Disc Linings Pads	Operation, adjustment, damage parts and leakage
L	Air pollution control (1968 and later models)	Operation and installation
M	Fuel tank and cap	Mounting and leakage

Source: Missouri State Highway Patrol, Motor Vehicle Inspection Divisions.

Table A-2. ESTIMATED DURATION AND THROUGHPUT OF INSPECTION PROGRAMS

Locale	Program	Duration,[a] minutes	Throughput,[b] vehicle/minute
New Jersey	Combined safety and idle mode emission inspection	6	1/1.5
Arizona	Loaded mode emission inspection	6	1/3
Arizona	Motor vehicle safety and emission diagnostic inspection demonstration project	25-30	1/8
Oregon	Idle mode emission inspection	4-5	1/3
California	Riverside pilot program - loaded mode emission inspection	6-8	1/3
Cincinnati	Combined safety and idle mode emission inspection	4	1/2
Nevada	Private garage idle mode emission inspection w/adjustments	20-25	NA
Massachusetts	Private garage safety inspection program	8-10	NA
Missouri	Private garage safety inspection program	20	NA

[a] Time for inspection, only, does not include waiting time.

[b] Potential throughput for inspection test lanes, does not consider influence of downtime and assumes vehicle always waiting for inspection.

NA - Not applicable.

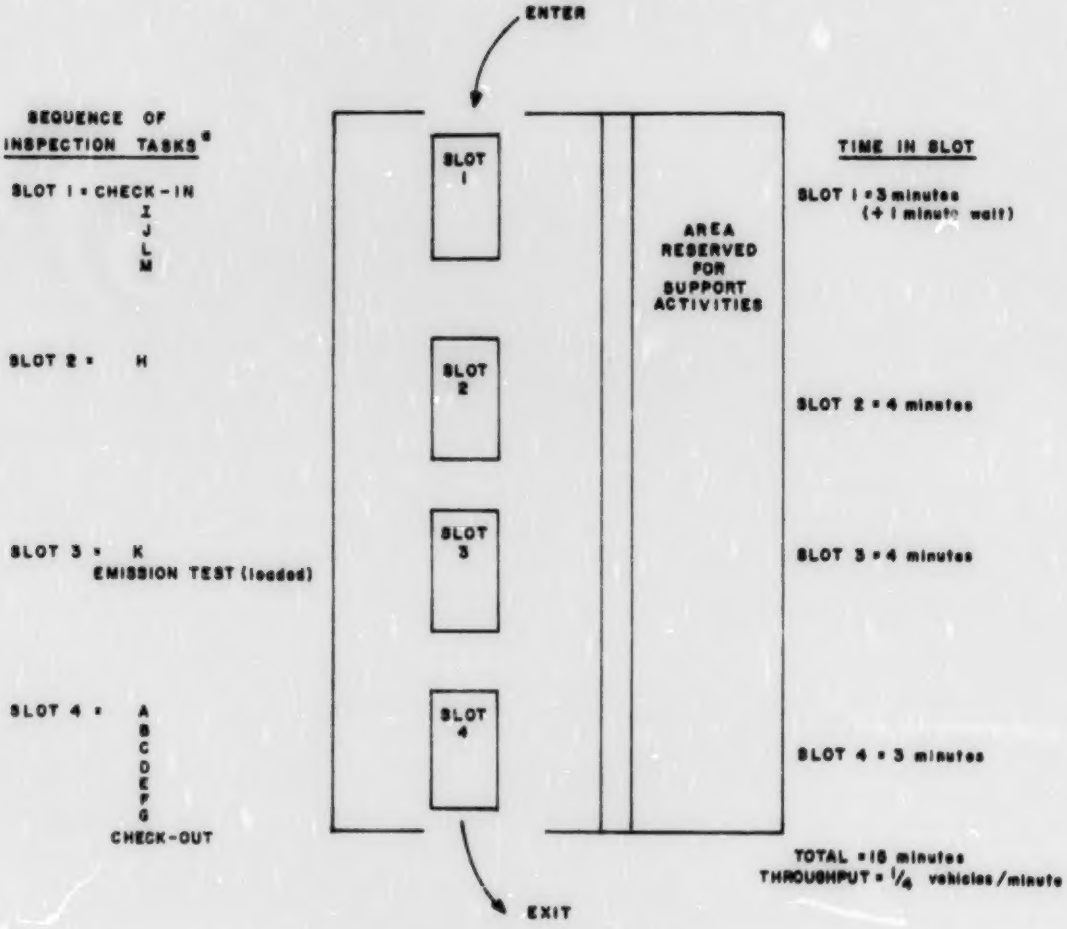
Those programs which are conducted by private garages consume more time. Time requirements range from approximately 8 to 10 minutes for the limited Massachusetts safety inspection to 20 to 25 minutes for the Nevada emission inspection program. The Nevada program includes a check and an adjustment, if needed, of vehicle timing and idling to applicable manufacturers' specifications. Approximately 20 minutes are required to perform a complete safety inspection in Missouri within the present guidelines. It is estimated that approximately 10 to 12 minutes would be needed if the Missouri program were conducted in centralized inspection lanes.

The Sequence of Inspection Tasks - Once the type and extent of the inspection program has been established, the sequence of the inspection tasks can be planned. The objective is to maximize the vehicle throughput of the test lane.

There are two major considerations with regards to determining inspection time and throughput. Accurate task duration should be determined from actual time studies. For the purposes of this report, estimates of task time were based on the time usage of existing programs as summarized in Table A-2.

The second issue deals with task aggregation. Task groupings should be logical and enhance total efficiency. For example, vision and signal lighting equipment can be inspected together. The total inspection time should be allocated so that vehicles spend approximately equal time in each slot to maximize vehicle throughput. The objective of lane design is to logically aggregate tasks into slots while minimizing inspection time and maximizing vehicle throughput.

Loaded inspection lane design - Figure A-1 provides a diagram of a single lane inspection facility for the loaded mode alternative. A few of the important characteristics of this lane design will be noted.


ENTER
SEQUENCE OF INSPECTION TASKS[a]
SLOT 1 = CHECK-IN
I
J
L
M
SLOT 2 = H
SLOT 3 = K
EMISSION TEST (loaded)
SLOT 4 = A
B
C
D
E
F
G
CHECK-OUT
SLOT 1
SLOT 2
SLOT 3
SLOT 4
AREA RESERVED FOR SUPPORT ACTIVITIES
TIME IN SLOT
SLOT 1 = 3 minutes (+ 1 minute wait)
SLOT 2 = 4 minutes
SLOT 3 = 4 minutes
SLOT 4 = 3 minutes
TOTAL = 15 minutes
THROUGHPUT = 1/4 vehicles/minute
EXIT

[a] FOR CODE DEFINITION REFER TO TABLE A-1

Figure A-1. Sequencing schematic diagram: loaded mode inspection lane

The loaded mode test requires the use of a dynamometer to simulate driving conditions. The loaded emission test is grouped with the brake inspection in slot 3 because the dynamometer can also be used to measure brake performance. This grouping eliminates equipment duplication.

The conduct of Task J (tires and wheels) must be performed prior to the loaded mode emission test. Safety precautions require one to ascertain proper tire condition prior to placing a vehicle on the dynamometer.

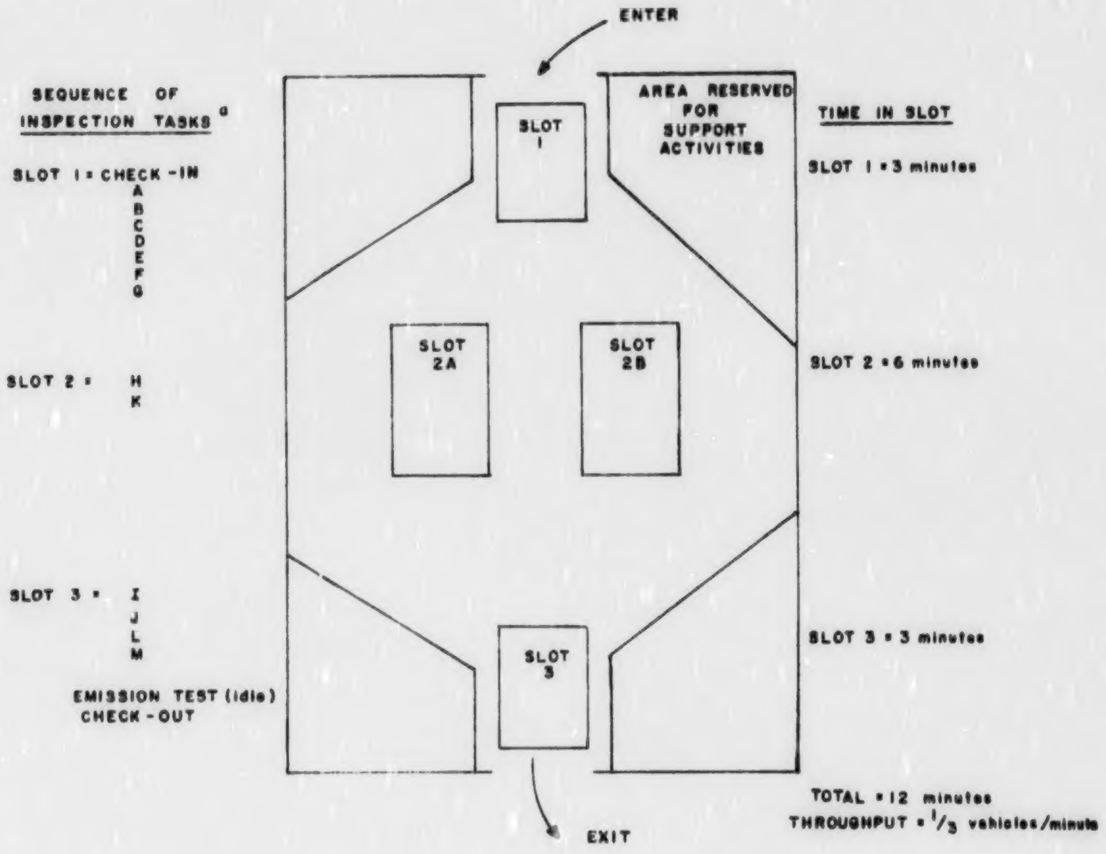
Idle inspection lane design - Figure A-2 provides a diagram of a single lane inspection facility for the idle mode alternative. This design differs from the previous design due to variations in the emission test procedures.

The idle mode procedure is less time consuming than the loaded mode test, permitting the elimination of one slot in the inspection process. A nontraditional lane design for the idle mode alternative is selected in order to decrease total time and improve vehicle throughput. Both Tasks H (steering mechanisms) and K (brakes) require the use of a lift. Savings in total time accrue if the vehicle need not be lifted, inspected and dropped for Task H and then moved and relifted for Task K. The side-by-side design is one way of improving the efficiency of the lane and maximizes vehicle throughput.

An idle emission test can be effectively performed by the same inspection technician who inspects the air pollution control devices. Therefore, the idle emission test is grouped with Task L (air pollution control devices) in contrast with the loaded inspection lane design.

Calculation of Vehicle Throughput

As shown by Figure A-1, the loaded mode test takes approximately 15 minutes to perform. Given the design of the lane, this implies a throughput of one vehicle every 4 minutes.


ENTER
SEQUENCE OF INSPECTION TASKS[a]
SLOT 1 = CHECK-IN
A
B
C
D
E
F
G
SLOT 2 = H
K
SLOT 3 = I
J
L
M
EMISSION TEST (idle)
CHECK-OUT
SLOT 1
SLOT 2A
SLOT 2B
SLOT 3
AREA RESERVED FOR SUPPORT ACTIVITIES
TIME IN SLOT
SLOT 1 = 3 minutes
SLOT 2 = 6 minutes
SLOT 3 = 3 minutes
TOTAL = 12 minutes
THROUGHPUT = 1/3 vehicles/minute
EXIT

[a] FOR CODE DEFINITION REFER TO TABLE A-1

Figure A-2. Sequencing schematic diagram: idle mode inspection lane

The idle mode inspection alternative, shown in Figure A-2, requires 12 minutes. The throughput is one vehicle every 3 minutes.

ANNUAL INSPECTION LANE CAPACITY

The annual capacity of an inspection lane is a function of its vehicle throughput and its operating hours.

Operating Hour Assumptions

The actual operating hours of a test facility may vary by location. Inspection facilities in St. Louis City may warrant different hours than the facilities located in St. Louis County. Other possible policies would include variations in operating hours based on facility size or standard hours selected for all facilities.

It has been assumed here that facilities operate for 8 hours per day and for 25 days per month, yielding an operating time of 200 hours per month. This is equivalent to 48 operating hours during a typical week. The 25-day-per-month assumption is derived by subtracting 1 normal, non-operating day per week plus one holiday each month.

Annual Lane Capacity

Table A-3 presents the annual inspection lane capacity computations for the two alternatives. The theoretical capacity is the product of the vehicle throughput and the annual operating hours. An efficiency factor is required to account for inefficiencies in the operations and is applied to the theoretical capacity to yield the practical capacity of the inspection. The practical capacity for the loaded mode and idle mode alternatives are 24,000 vehicle per year and 32,000 vehicles per year, respectively.

Table A-3. INSPECTION LANE ANNUAL CAPACITY

	Loaded mode alternative	Idle mode alternative
Throughput, veh/min	1/4	1/3
x minute/hr	60	60
Hourly capacity, vehicles	15	20
x operating hours/day	8	8
Daily capacity, vehicles	120	160
x operating days/month	25	25
Monthly capacity, vehicles	3,000	4,000
x operating months/year	12	12
Annual capacity,[a] vehicles	36,000	48,000
x efficiency factor[b]	66.7	66.7
Annual capacity,[c] vehicles	24,000	32,000

[a] Theoretical annual capacity.

[b] Factor to account for inefficiencies in operation due to a noncontinuous stream of vehicles and equipment and personnel downtime.

[c] Practical annual capacity.

ANNUAL NETWORK CAPACITY

The total number of inspection lanes required, or network capacity, is a function of the practical annual capacity of a lane and the total demand for inspections. Demand is defined as a sum of the net vehicle population to be inspected plus a factor for retests. The objective of network design is to provide sufficient network capacity for inspection of all vehicles.

Vehicle Inspection Assumptions

The 1975 vehicle population is estimated from Missouri Department of Revenue, Motor Vehicle Bureau statistics to be 753,000 vehicles. This total includes those passenger vehicles and light trucks of less than 8501 pounds Gross Vehicle Weight registered within St. Louis City and County.

The 1980 vehicle population to be tested includes the same vehicle types. The forecast for the 1980 vehicle population, 920,000 vehicles, is based on a 4 percent annual growth in vehicle registration from 1975.

An additional percentage to account for retests must be added to the vehicle population tested to realize total inspections. It is assumed that 30 percent of the vehicles tested will need some form of repair. Under the state or contractor run, retests will be done by private garages certified to perform vehicle repairs. However, the consumer will be given the option of choosing between the private garage or the centralized inspection lane for the reinspection of the vehicle. Based on New Jersey estimates, where a similar option is practiced, retests are divided evenly between the private garages and the central inspection lanes.* This results in 138,000 reinspections and a total in 1980 of 1,058 vehicle inspections, as shown in Table A-4.

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*Reference: Personal communication with Mr. John A. Elston, New Jersey Department of Environmental Protection, Bureau of Air Pollution Control, September 16, 1976.

Table A-4. TEST LANE REQUIREMENTS

	Loaded mode alternative	Idle mode alternative
1975 net vehicle population less than 6001 lb GVW	753,000	753,000
Annual growth factor	4%	4%
1980 net vehicle population less than 6001 lb GVW	920,000	920,000
Percent of vehicles requiring maintenance, design rate	30%	30%
Number of vehicles requiring maintenance	276,000	276,000
Retest factor	50%	50%
Number of retests at inspection lanes	138,000	138,000
1980 vehicle inspections at inspection lanes	1,058,000	1,058,000
Annual inspection lane capacity	24,000	32,000
Number of inspection lanes (1980)	44	33

Number of Inspection Lanes

Table A-4 also presents the calculations for the actual number of required inspection lanes. The results are produced from the division of total vehicle inspections by annual inspection lane capacity. Totals of 44 and 33 inspection lanes are required for the loaded mode and idle mode alternatives, respectively.

FACILITY SITING AND LANE DISTRIBUTION

This section is concerned with siting the inspection lane facilities, and with distributing the required number of lanes among the facilities. Sites are located by cities selected as best representing the intended service areas. Searches for appropriate building plots would occur within the recommended city or reasonable vicinity.

Siting and Distribution Criteria

It would be most convenient for the public if the lanes are distributed as single-lane facilities. This convenience, however, is offset by cost considerations. It is prudent to plan multilane-inspection facilities in order to benefit from economies of scale.

The following are the criteria which were used to distribute and site the inspection facilities in the St. Louis area:

- Approximately 90 percent of the population resides within 5 miles of an inspection facility.
- Approximately 100 percent of the population resides within 10 miles of an inspection facility.
- A maximum of four lanes are assigned per inspection facility.
- Inspection facilities are sited no closer than 3 miles apart.
- Inspection facilities are generally sited within the more populous community of a service area.
- The number of lanes assigned to a site are approximately proportional to the population in that service area.
- Service areas are identifiable by appropriate boundaries (e.g., political, topographical, or transportation boundaries).

Population statistics from the 1970 U.S. Census and a basic highway map of the St. Louis area were used to determine population densities, to identify population centers and to define service areas.

Facility Siting and Lane Distribution Results

The use of the above criteria results in the siting and distribution of lanes as listed in Table A-5. The inspection facility locations are plotted in Figures IV-1 and IV-2 of this report for the loaded mode and idle mode alternatives, respectively. The final siting provides inspection facilities within 2 miles of the residency of the denser urbanized population. This area encompasses most of St. Louis City plus the contiguous St. Louis County communities. The remaining residents in the urbanized portion of St. Louis City and County are within 5 miles of an inspection facility. The population of the outlying districts of St. Louis County are served by facilities located within 10 miles of their homes.

The site locations selected provide reasonable convenience while the assigned lanes at each site provides sufficient capacity for the intended service area. The final distribution of the test lanes which matches the population distribution is as follows:

- 60 percent within the denser urbanized portion
- 35 percent within the remaining urbanized portion
- 5 percent within the outlying districts

SUMMARY

The parameters of the resultant inspection facility network are summarized in Tables A-6 and A-7. Table A-6 provides a summary of lane capacity and requirements. The total number of lanes required are 44 and 33 for the loaded mode and idle mode alternatives, respectively. These lane requirements were based on 1,058,000 annual inspections in 1980 and practical annual capacities of 24,000 and 32,000 for the loaded and idle mode inspection lanes, respectively. The annual capacity of an inspection lane is a function of the vehicle throughput and operating hours.

Table A-5. INSPECTION LANE SITING AND DISTRIBUTION

Facility location		Number of lanes	
No.	City[a]	Loaded mode alternative	Idle mode alternative
1	St. Louis	4	4
2	St. Louis	4	4
3	St. Louis	4	4
4	Florissant	2	
5	Florissant		4
6	Hazelwood	4	
7	Jennings	4	3
8	Edmundson	4	3
9	Wellston	2	
10	Creve Coeur	3	2
11	Ladue	4	4
12	Kirkwood	3	
13	Lemay	4	
14	Sappington		4
15	Ballwin	2	1
		44	33

[a] Facilities to be located in the vicinity of the identified city as plotted in Figures IV-1 and IV-2.

Table A-6. SUMMARY OF LANE CAPACITY AND REQUIREMENTS

	Loaded mode alternative	Idle mode alternative
Vehicle throughput	1/4	1/3
Practical annual capacity	24,000	32,000
Annual vehicle inspection 1980	1,058,000	1,058,000
Lane requirements	44	33

Table A-7. SUMMARY OF LANE SITING AND DISTRIBUTION

	Number of facilities	
Number of lanes/facility	Loaded mode alternative	Idle mode alternative
1	0	1
2	3	1
3	2	2
4	8	6
Total	13	10

The summary of the lane siting and distribution is presented by Table A-7. The results show the number of inspection facilities and the number of lanes assigned to each facility. The loaded mode alternative is composed of a 13-facility network with three 2-lane, two 3-lane and eight 4-lane inspection facilities. The idle mode alternative consists of one 1-lane, one 2-lane, two 3-lane, and six 4-lane inspection facilities, 10-facility network. Each network provides more than adequate coverage for the entire St. Louis area.

APPENDIX B

CALCULATIONS OF COSTS ASSOCIATED WITH TEST LANES

Table B-1. EFFECT OF THE NUMBER OF LICENSEES ON THE TIME SPENT ON INSPECTION FOR EACH STATION

	Number of stations		
	1500	1000	500
Cars inspected/station/year			
Initial inspections	613	920	1840
30% failure	184	276	552
-46% carburetor adjustment[a]	85	127	254
-34% minor tune-up	63	94	188
-16% major tune-up	29	44	88
-4% engine overhaul	7	11	22
Total inspections, including reinspection[b]	705	1058	2116
Hours spent/station/year			
All inspections[c]	293.8	440.8	881.6
Carburetor adjustments[d]	7.1	10.6	21.2
Total	300.9	451.4	902.8
Average hours per day	1	1.5	3

[a] Distribution of type of repairs from "New Jersey's Auto Emission Inspection Program: An Assessment of One Year's Mandatory Operation" by John C. Elston and Daniel Cowperthwait, Paper No. 75-42.3 presented at the annual meeting of the Air Pollution Control Association. June 1975.

[b] It is assumed that only vehicles requiring either a major or a minor tune-up will come back for a retest. Carburetor adjustments will be done at the time of the inspection. Vehicles requiring engine overhaul will likely be exempted from the program.

[c] Assumed inspection time of 25 minutes.

[d] Assumed adjustment time of 5 minutes.

Table B-2. COSTS ASSOCIATED WITH PRIVATELY RUN STATIONS

	Number of stations		
	1500 $	1000 $	500 $
Capital			
Equipment			
Emissions analyzer	2,200	2,200	2,200
Safety inspection equipment	300	300	300
Total	2,500	2,500	2,500
Annual			
Fee	25	25	25
Maintenance and amortization	500	500	500
Labor[a]	3,552	4,880	9,759
Total	4,077	5,405	10,284

[a] Annual hours (excluding carburetor adjustment) multiplied by $11.07 $11.07 the wage rate plus overhead charges. Wage estimates obtained from An Analysis of the Practical Application of An Inspection and Maintenance Program in the Public and Private Sectors (Draft), Automotive Testing Laboratories, Inc. Prepared for Colorado Department of Health. Adjusted for St. Louis.

Table B-3. STATE COSTS FOR PRIVATELY-RUN SYSTEM

	Number of stations		
	1500 $	1000 $	500 $
Capital costs			
Equipment[a]	84,000	60,000	36,000
Mechanic training[b]	16,000	16,000	16,000
Public relations[c]	100,000	100,000	100,000
Total	200,000	176,000	152,000
Annual costs			
Administration[d]	304,000	304,000	304,000
Surveillance[e]	119,000	90,000	44,000
Public relations[f]	60,000	60,000	60,000
Annualized capital and interest[g]	51,000	45,000	39,000
Total	534,000	499,000	447,000

[a] Purchase of mobile standards laboratories at $12,000 each for technicians performing station surveillance and equipment calibration. Source: An Analysis of the Practical Application of an I/M Program in the Public and Private Sectors (Draft). Automotive Testing Laboratories, Inc., Colorado. Prepared for Colorado Department of Health.

[b] Training of 4000 mechanics. Assumes 8-hour training sessions. Cost includes salary for instructor plus 20 percent for course materials. Does not include mechanics' wages.

[c] Assumes $0.10 per vehicle for press releases, public service announcement preparation for radio and television, audiovisual presentations. Based on estimate in "Evaluation of Mandatory Vehicle Inspection and Maintenance Programs," Air Resources Board, State of California.

Table B-3 (continued). STATE COSTS FOR PRIVATELY-RUN SYSTEM

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[d] Administrative costs

Number of people	Position	Salary $
1	Administrator	20,000
1	Assistant Administrator	17,000
4		15,000
2	Data Analysts	15,000
1	Supervisor of keypunch staff	13,000
16	Keypunch operators	8,000
4	Secretaries	9,000

[e] Includes salaries and fringe benefits for staff consisting of a supervisor and technicians. The first case of 1500 stations requires 7 technicians to perform equipment calibration; the second case requires 5 technicians and the last case 3 technicians. Based on calibration for each station every 2 months with each technician being able to perform 1300 inspections per year. Estimates obtained from Automotive Testing Labs, op. cit.

[f] Assumes \$0.06 per vehicle. Estimate from California Air Resources Board, op. cit.

[g] Assumes loan repayment over 5 years with annual payments and 8.5 percent interest. The equation used to determine this is:

$$PV = PMT \left[\frac{\left(1 + \frac{i}{100N}\right)^{YN} - 1}{\frac{i}{100N}\left(1 + \frac{i}{100N}\right)^{YN}} \right]$$

where PV = Principal value

PMT = Periodic payment

i = Annual interest rate in percent

Y = Number of year

N = Number of payment periods per year

equation was solved for PMT.

Table B-4. COSTS ASSOCIATED WITH IDLE MODE TEST FACILITIES

	Lanes per facility			
	One lane	Two lanes	Three lanes	Four lanes
Capital costs				
Building[a]	$84,000	$154,000	$210,000	$259,000
Land[b]	38,400	70,400	96,000	118,400
Equipment				
Emission analyzers at $2,200	2,200	4,400	6,600	8,800
Safety inspection equipment at $2,800[c]	2,800	5,600	8,400	11,200
Data handling system at $25,000[d]	25,000	50,000	75,000	100,000
Office equipment and other supplies[d]	1,000	1,500	2,000	2,500
Total	$153,400	$285,900	$398,000	$499,900
Operating costs				
Salaries[e]	$78,400	$152,300	$201,000	$291,200
Equipment repair and replacement[f]	6,000	12,000	18,000	24,000
Utilities and supplies[g]	7,000	8,000	9,000	10,000
Total	$91,400	$172,300	$228,000	$325,200

[a] The building cost is $35/ft^2; estimate was obtained from the St. Louis County Assessors Office.

[b] A 4 to 1 land to building ratio has been assumed. The land costs in the St. Louis area range from less than $1/ft^2 to $30/ft^2. A reasonable estimate, according to a representative of the St. Louis County Assessors Office, of the price of a small parcel in a prime location (i.e., on a main road with good access) is $4/ft^2. Estimates were obtained from the St. Louis County and St. Louis City Assessors Offices.

Table B-4 (continued). COST ASSOCIATED WITH IDLE MODE TEST FACILITIES

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[c] Safety inspection equipment includes:

• brake lining gauge	$ 7
• brake pad gauge	65
• ball joint gauge	35
• toe-in/toe-out gauge	88
• brake meter	95
• lift (in-ground, single post)	2,400
• miscellaneous tools (screwdrivers, wrenches, etc.)	100
	$2,790

Estimates obtained from Company A and Company B.

[d] Estimate obtained from "An Analysis of the Practical Application of an Inspection and Maintenance Program in the Public and Private Sectors" draft report prepared for State of Colorado by Automotive Testing Laboratories, Inc.

Table B-4 (continued). COST ASSOCIATED WITH IDLE MODE TEST FACILITIES

e Personnel requirements

Lanes	Number of people			
	1	2	3	4
Supervisor at $16,000	1	1	1	1
Senior Technicians at $13,000	1	2	3	5
Technicians at $11,000	1FT,1PT*	6FT,1PT*	10FT,2PT*	12FT,2PT*
Clerks at $9,000	1FT,1PT	2FT,1PT	3FT,2PT	3FT,1PT
Total Salary Expense	$70,000	$136,000	$201,000	$260,000
Plus 12 percent fringe benefits**	$78,400	$152,320	$225,120	$291,200

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[*] FT denotes full time; PT part time.

[**] Estimates of fringe benefits from Handbook of Labor Statistics 1975. U.S. Department of Labor, Bureau of Labor Statistics.

[f] Estimated to be 20 percent of equipment cost. Based on California and New Jersey findings.

[g] Based on estimates in Automotive Testing Laboratories, Colorado, op. cit.

Table B-5. COSTS ASSOCIATED WITH LOADED MODE TEST FACILITIES

	Lanes per facility			
	One lane	Two lanes	Three lanes	Four lanes
Capital costs				
Building[a]	$ 84,000	$154,000	$210,000	$259,000
Land[b]	38,400	70,400	96,000	118,400
Equipment				
Emissions analyzers at $2,200	2,200	4,400	6,600	8,800
Dynamometers at $10,000	10,000	20,000	30,000	40,000
Safety inspection equipment[c]	2,800	5,600	8,400	11,200
Data handling system at $25,000[d]	25,000	50,000	75,000	100,000
Office equipment and other supplies[d]	1,000	1,500	2,000	2,500
Total	$163,400	$305,900	$418,000	$519,900
Operating costs				
Salaries[e]	$ 78,400	$152,300	$201,000	$291,200
Equipment repair and replacement[f]	8,000	16,000	24,000	32,000
Utilities and supplies[g]	7,000	8,000	9,000	10,000
Total	$ 93,400	$176,300	$234,000	$333,200

[a] The building cost is $35/ft^2$; estimate was obtained from the St. Louis County Assessors Office.

[b] A 4 to 1 land to building ratio has been assumed. The land costs in the St. Louis area range from less than $1/ft^2$ to $30/ft^2$. A reasonable estimate, according to a representative of the St. Louis County Assessors Office, of the price of a small parcel in a prime location (i.e., on a main road with good access) is $4/ft^2$. Estimates were obtained from the St. Louis County and St. Louis City Assessors Offices.

Table B-5 (continued). COSTS ASSOCIATED WITH LOADED MODE TEST FACILITIES

---

[c] Safety inspection equipment includes:

- brake lining gauge	$ 7
- brake pad gauge	65
- ball joint gauge	35
- toe-in/toe-out gauge	88
- brake meter	95
- lift (in-ground, single post)	2,400
- miscellaneous tools (screw drivers, wrenches, etc.)	100
	$2,780

Estimates obtained from Company A and Company B.

[d] Estimate obtained from "An Analysis of the Practical Application of an Inspection and Maintenance Program in the Public and Private Sectors" draft report prepared for the State of Colorado by Automotive Testing Laboratories, Inc.

Table B-5 (continued). COST ASSOCIATED WITH LOADED MODE TEST FACILITIES

e Personnel requirements

Lanes	Number of people			
	1	2	3	4
Supervisor at $16,000	1	1	1	1
Senior Technicians at $13,000	1	2	3	5
Technicians at $11,000	1FT,1PT*	6FT,1PT*	10FT,2PT*	12FT,2PT*
Clerks at $9,000	1FT,1PT	2FT,1PT	3FT,2PT	3FT,1PT
Total Salary Expense	$70,000	$136,000	$201,000	$260,000
Plus 12 percent fringe benefits**	$78,400	$152,320	$225,120	$291,200

[*] Denotes full time; PT part time.

[**] Estimates of fringe benefits from Handbook of Labor Statistics 1975. U.S. Department of Labor, Bureau of Labor Statistics.

[f] Estimated to be 20 percent of equipment cost. Based on California and New Jersey findings.

[g] Based on estimates in Automotive Testing Laboratories, Colorado, op. cit.

Table B-6. CENTRAL TEST LANE PROGRAM COSTS

	State-run		Contractor-run	
	Idle mode	Loaded mode	Idle mode	Loaded mode
Capital costs				
Public relations[a]	$100,000	$ 100,000	$100,000	$ 100,000
Inspector training[b]	55,000	73,000	55,000	73,000
Land acquisition[c]	4,000	4,000	2,500	2,500
Program design[d]	200,000	200,000	-	-
Total	$360,000	$ 378,000	$157,500	$ 175,500
Annual costs				
Public relations[e]	$ 60,000	$ 60,000	$ 60,000	$ 60,000
Data handling[f]	17,000	17,000	17,000	17,000
Annualized capital cost plus interest[g]	700,400	958,800	669,500	927,900
Total	$777,400	$1,035,800	$746,500	$1,004,900

[a] Assumes $0.10 per vehicle for press releases, public service announcement preparation for radio and television, audiovisual presentations. Based on estimates in "Evaluation of Mandatory Vehicle Inspection and Maintenance Programs," Air Resources Board, State of California, May 1976.

[b] Assumes 40-hour training session for 156 inspectors for idle mode, 209 inspectors for loaded mode. Estimate includes instructor's salary plus 20 percent for course materials.

[c] Assumes two person months for station location and price negotiation. In addition, for the state-run, the State of Missouri requires two or three appraisals for each parcel; the average appraisal fee is $150. Estimate of appraisal fee obtained from State Office of Administration.

Table B-6 (continued). CENTRAL TEST LANE PROGRAM COSTS

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[d] For contractual assistance to the state in the actual design of the program.

[e] Assumes \$0.06 per vehicle. Based on California Report, op. cit.

[f] Includes salary and fringe benefits for a data analyst. Computer time expense not included.

[g] The annualized capital cost plus interest is the repayment of the loan needed to obtain the necessary capital costs (i.e., the program capital costs plus the capital costs associated with the test lanes). It is assumed that this entire sum is financed by a 10-year loan to be repaid in annual payments at an 8.5 percent interest rate. The equation used to determine this is:

$$PV = PMT \left[\frac{\left(1 + \frac{i}{100N}\right)^{YN} - 1}{\frac{i}{100N}\left(1 + \frac{i}{100N}\right)^{YN}} \right],$$

where PV = Principal value

PMT = Periodic payment

i = Annual interest rate in percent

Y = number of years

N = Number of payment periods per year

the equation is solved for PMT.

Table B-7. STATE ADMINISTRATIVE COSTS, CENTRAL TEST LANES

	Cost
Capital	
Mechanic training[a]	$ 16,000
Operating	$139,000
Administrative staff	
Administrator	$ 20,000
Assistant administrator	17,000
Four other professionals	60,000
Three secretaries	27,000
	$124,000
Fringe benefits (12% of salaries)	14,880
	$138,000

[a] Training of 4000 mechanics. Assumes 8-hour training session. Cost include salary for instructor plus 20 percent for course materials. Does not include mechanics wages.

Table B-8. EXAMPLE CALCULATION OF TOTAL SYSTEM COST

State-run idle mode			
A Lanes per station	B Number of stations	C Per station operating cost	D Total
1	1	91,400	$ 91,400
2	1	172,300	172,300
3	2	228,000	456,000
4	6	325,200	1,951,200
Sum of station operating costs			$2,670,900
Annualized program costs			$ 777,400
Total annual system cost			$3,448,300
Annual state administrative cost			$ 138,880
Total annual cost			$3,587,180
Inspection fee $\left(\frac{\text{total annual cost}}{\text{vehicle population}}\right)$			$ 3.90

Table B-9. EFFECT OF THE NUMBER OF STATIONS LICENSED ON THE INSPECTION FEE

	Number of stations licensed			
	100	200	500	1000
Reinspections/station/year	1380	690	276	138
Annual cost/station	7253	3364	1871	1198
Inspection fee[a]	5.26	5.64	6.78	8.68

[a] Annual cost per vehicle inspected.

APPENDIX C

CALCULATION OF EMISSIONS REDUCTION

The following computer program written by GCA was used to calculate the emission reductions from an inspection/maintenance program.

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0001                DIMENSION EF(14,3,12,2), EMISS(12,33),
                   X           EFC71(14,3), EFC72(14,3), EFC73(14,3), EFC74(14,3),
                   X           EFC75(14,3), EFC76(14,3), EFC77(14,3), EFC78(14,3),
                   X           EFC79(14,3), EFC80(14,3), EFC85(14,3), EFC90(14,3),
                   X           EFT71(14,3), EFT72(14,3), EFT73(14,3), EFT74(14,3),
                   X           EFT75(14,3), EFT76(14,3), EFT77(14,3), EFT78(14,3),
                   X           EFT79(14,3), EFT80(14,3), EFT85(14,3), EFT90(14,3)
0002                EQUIVALENCE (EFC71(1),EF(1,1,1,1)), (EFT71(1),EF(1,1,1,2)),
                   X          (EFC72(1),EF(1,1,2,1)), (EFT72(1),EF(1,1,2,2)),
                   X          (EFC73(1),EF(1,1,3,1)), (EFT73(1),EF(1,1,3,2)),
                   X          (EFC74(1),EF(1,1,4,1)), (EFT74(1),EF(1,1,4,2)),
                   X          (EFC75(1),EF(1,1,5,1)), (EFT75(1),EF(1,1,5,2)),
                   X          (EFC76(1),EF(1,1,6,1)), (EFT76(1),EF(1,1,6,2)),
                   X          (EFC77(1),EF(1,1,7,1)), (EFT77(1),EF(1,1,7,2)),
                   X          (EFC78(1),EF(1,1,8,1)), (EFT78(1),EF(1,1,8,2)),
                   X          (EFC79(1),EF(1,1,9,1)), (EFT79(1),EF(1,1,9,2)),
                   X          (EFC80(1),EF(1,1,10,1)),(EFT80(1),EF(1,1,10,2)),
                   X          (EFC85(1),EF(1,1,11,1)),(EFT85(1),EF(1,1,11,2)),
                   X          (EFC90(1),EF(1,1,12,1)),(EFT90(1),EF(1,1,12,2))
              C-ARRAY EF CONTAINS FTP EMISSION FACTORS FOR 14 MODEL YEARS, 3 POLLUTANTS,
              C      12 CALENDAR YEARS, AND 2 VEHICLE TYPES.  EQUIVALENT ARRAYS EFC71-90
              C      AND EFT71-90 ARE USED FOR DATA STATEMENT INPUT OF THE EMISSION
              C      FACTORS.  ARRAY EMISS IS FOR OUTPUT MATRIX - 12 CALENDAR YEARS
              C      BY 33 MODEL YEARS 1958 - 1990.
              C
0003                DATA EFC71/39.6, 47.6, 61.7, 67.8, 10*86.5,                          71 CO
                   X         3.07, 3.77, 5.19, 5.54, 10*8.74,                            71 HC
                   X         5.06, 5.15, 5.45, 4.34, 10*3.54/                            71 NOX
0004                DATA EFC72/36.9, 51.1, 53.2, 64.2, 63.7, 9*93.5,                     72 CO
                   X         3.02, 3.94, 4.89, 4.95, 6.33, 9*8.67,                       72 HC
                   X         4.55, 4.30, 4.35, 5.00, 4.44, 9*3.34/                       72 NOX
0005                DATA EFC73/37.0, 39.0, 53.5, 56.0, 65.4, 67.6, 8*94.0,               73 CO
                   X         3.20, 3.50, 4.30, 5.30, 5.30, 6.80, 8*8.80,                 73 HC
                   X         3.11, 4.55, 4.30, 4.35, 5.08, 4.32, 8*3.34/                 73 NOX
0006                DATA EFC74/37.0, 39.0, 41.0, 56.0, 58.5, 68.4, 70.6, 7*95.0,         74 CO
                   X         3.20, 3.50, 3.80, 4.70, 5.80, 5.80, 7.40, 7*8.90,           74 HC
                   X         3.10, 3.30, 4.55, 4.30, 4.35, 5.08, 4.32, 7*3.34/           74 NOX
0007                DATA EFC75/ 9.0, 39.0, 41.0, 43.0, 58.5, 61.0, 71.4, 73.6, 6*96.0, 75 CO
                   X         1.00, 3.50, 3.80, 4.10, 5.10, 6.30, 6.30, 8.00, 6*9.00, 75 HC
                   X         3.10, 3.30, 3.50, 4.55, 4.30, 4.35, 5.08, 4.32, 6*3.34/ 75 NOX
0008                DATA EFC76/9.0,9.9,41.0,43.0,45.0,61.0,63.5,74.4,76.6,5*97.0,        76 CO
                   X         1.0,1.2,3.80,4.10,4.40,5.50,6.80,6.80,8.60,5*9.10,          76 HC
                   X         3.1,3.2,3.50,3.70,4.55,4.30,4.35,5.08,4.32,5*3.34/          76 NOX
0009                DATA EFC77/9.0,9.9,10.8,43.0,45.0,47.0,63.5,66.0,77.4,79.6,4*98.0, 77 CO
                   X         1.0,1.2,1.4,4.1,4.4,4.7,5.9,7.3,7.3,9.2, 4*9.2,             77 HC
                   X         2.0,3.2,3.3,3.7,3.9,4.55,4.30,4.35,5.08,4.32,4*3.34/        77 NOX
0010                DATA EFC78/2.8,9.9,10.8,11.7,45.0,47.0,49.0,66.0,68.5,80.4,82.6,     78
                   X    3*99.0,0.27,1.2,1.4,1.6,4.4,4.7,5.0,6.3,7.8,7.8,9.3,3*9.3,       78
```

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                 X    0.24,2.06,3.3,3.4,3.9,4.1,4.55,4.30,4.35,5.08,4.32,3*3.34/      78
 0011             DATA EFC79/ 2.8, 3.1,10.8,11.7,12.6,47.0,49.0,51.0,68.5,71.0,       79 CO
                 X                   83.4,82.6,99.0,99.0,                              79 CO
                 X              0.27,0.32,1.4,1.5,1.8,4.7,5.0,5.3,6.7,                 79 HC
                 X                   8.3,8.3,9.3,9.3,9.3,                              79 HC
                 X              0.24,0.29,2.12,3.4,3.5,4.1,4.3,4.55,4.30,4.35,         79 NOX
                 X                   5.08,4.32,3.34,3.34/                              79 NOX
 0012             DATA EFC80/ 2.8, 3.1, 3.4,11.7,12.5,13.5,49.0,51.0,53.0,71.0,       80 CO
                 X                   73.5,83.4,82.6,99.0,                              80 CO
                 X              0.27,0.32,0.38,1.6,1.8,2.0,5.0,5.3,5.6,7.1,            80 HC
                 X                   8.8,8.3,9.3,9.3,                                  80 HC
                 X              0.24,0.29,0.34,2.18,3.5,3.6,4.3,4.5,4.55,4.30,         80 NOX
                 X                   4.35,5.08,4.32,3.34/                              80 NOX
 0013             DATA EFC85/ 2.8,3.1,3.4,3.6,3.9,4.2,4.5,4.8,16.2,17.1,18.0,3*57.0, 85 CO
                 X              0.27,0.32,0.38,0.43,0.49,0.54,0.59,0.65,2.6,2.8,3.0,   85 HC
                 X      3*6.2, 0.24,0.29,0.34,0.40,0.56,0.73,0.90,1.1,2.48,4.0,       85 NOX
                 X                   4.1,5.0,5.0,4.55/                                 85 NOX
 0014             DATA EFC90/2.8,3.1,3.4,3.6,3.9,4.2,4.5,4.8,5.0,5.3,3*5.6,18.0,      90 CO
                 X     0.27,0.32,0.38,0.43,0.49,0.54,0.59,0.65,0.70,0.76,3*0.81,3.0, 90 HC
                 X     0.24,0.29,0.34,0.40,0.56,0.73,0.90,1.10,1.30,1.50,3*1.70,2.6/ 90 NOX
            C
 0015             DATA EFT71/51.0, 51.0, 60.8, 63.0, 10*125.0,                        71 CO
                 X             3.7, 4.2, 4.7, 6.3, 10*17.0,                            71 HC
                 X             5.2, 5.2, 5.3, 4.9, 10*5.3/                             71 NOX
 0016             DATA EFT72/42.8, 53.5, 53.5, 64.3, 66.5, 9*125.0,                   72 CO
                 X             3.4, 4.2, 4.8, 5.3, 7.1, 9*17.0,                        72 HC
                 X             5.3, 5.2, 5.2, 5.3, 4.9, 9*4.2/                         72 NOX
 0017             DATA EFT73/42.8,45.0,56.0,56.0,67.8,70.0, 8*125.0,                  73 CO
                 X              3.6, 3.8, 4.7, 5.4, 5.9, 7.9, 8*17.0,                  73 HC
                 X              4.4, 5.3, 5.2, 5.2, 5.3, 4.9, 8*4.2/                   73 NOX
 0018             DATA EFT74/42.8,45.0,47.2,58.5,58.5,71.3,73.5,7*125.0,              74 CO
                 X             3.6,4.0,4.2,5.2,6.0,6.5,8.7,7*17.0,                     74 HC
                 X             4.4,4.6,5.3,5.2,5.2,5.3,4.9,7*4.2/                      74 NOX
 0019             DATA EFT75/27.0,45.0,47.2,49.4,61.0,61.0,74.8,77.0,6*125.0,         75 CO
                 X             2.7,4.0,4.4,4.6,5.7,6.6,7.1,9.5,6*17.0,                 75 HC
                 X             4.4,4.6,4.8,5.3,5.2,5.2,5.3,4.9,6*4.2/                  75 NOX
 0020             DATA EFT76/27.0,28.5,47.2,49.4,51.6,63.5,63.5,78.3,80.5,5*125.0,    76 CO
                 X             2.7,3.0,4.4,4.8,5.0,6.2,7.2,7.7,10.3,5*17.0,            76 HC
                 X             4.4,4.6,4.8,5.0,5.3,5.2,5.2,5.3,4.9,5*4.2/              76 NOX
 0021             DATA EFT77/27.0,28.5,30.0,49.4,51.6,53.8,66.0,66.0,81.8,84.0,       77 CO
                 X   4*125.0,2.7,3.0,3.3,4.8,5.2,5.4,6.7,7.8,8.3,11.1,4*17.0,          77 HC
                 X             4.4,4.6,4.8,5.0,5.2,5.3,5.2,5.2,5.3,4.9,4*4.2/          77 NOX
 0022             DATA EFT78/9.8,28.5,30.0,31.5,51.6,53.8,56.0,68.5,68.5,85.3,87.5,  78 CO
                 X   3*125.0,1.0,3.0,3.3,3.6,5.2,5.6,5.8,7.2,8.4,8.9,11.9,3*17.0,      78 HC
                 X          2.3,4.6,4.8,5.0,5.2,5.4,5.3,5.2,5.2,5.3,4.9,3*4.2/         78 NOX
 0023             DATA EFT79/9.8,10.8,30.0,31.5,33.0,53.8,56.0,58.2,2*71.0,88.8,      79 CO
                 X 87.5,2*125.0,1.0,1.2,3.3,3.6,3.9,5.6,6.0,6.2,7.7,9.0,9.5,11.9,      79 HC
                 X 2*17.0,2.3,2.35,4.8,5.0,5.2,5.4,5.6,5.3,5.2,5.2,5.3,4.9,2*4.2/     79 NOX
 0024               DATA EFT80/9.8,10.8,11.8,31.5,33.0,34.5,56.0,58.2,60.4,2*73.5,      80 CO
                  X 88.8,87.5,125.0,1.0,1.2,1.4,3.6,3.9,4.2,6.0,6.4,6.6,8.2,9.6,9.5,   80
                  X 11.9,17.0, 2.3,2.35,2.4,5.0,5.2,5.4,5.6,5.8,5.3,5.2,5.2,5.3,       80
                  X 4.9,4.2/                                                            80
 0025               DATA EFT85/9.8,10.8,11.8,12.8,13.8,14.8,15.8,16.8,39.0,40.5,42.0,  85
                  X  3*64.8, 1.0,1.2,1.4,1.6,1.8,2.0,2.2,2.4,5.1,5.4,5.7,2*7.6,7.4,    85
                  X  2.3,2.35,2.4,2.45,2.5,2.55,2.6,2.65,6.0,6.2,3*6.4,5.3/            85
 0026               DATA EFT90/9.8,10.8,11.8,12.8,13.8,14.8,15.8,16.6,17.8,18.8,3*19.8 90
                  X  ,42.0, 1.0,1.2,1.4,1.6,1.8,2.0,2.2,2.4,2.6,2.8,3*3.0,5.7, 2.3,    90
                  X   2.35,2.4,2.45,2.5,2.55,2.6,2.65,2.7,2.75,2.8,2.8,2.8,6.4/        90
              C
              C***************************************************************************
              C
 0027               REAL IMEFF(12,3), IMEFFC(12,3)
 0028               DATA IMEFF/9*0.00, 0.160, 0.335, 0.405,
                  X           9*0.00, 0.100, 0.325, 0.415,
                  X           12*0.00/
 0029               DATA IMEFFC/9*0.00, 0.310, 0.485, 0.555,
                  X           9*0.00, 0.120, 0.345, 0.435,
                  X           12*0.00/
              C         ARRAYS IMEFF AND IMEFFC CONTAIN REDUCTIONS TO BE ATTRIBUTED TO
              C         THE I/M PROGRAM FOR 3 POLL IN 12 CALENDAR YEARS -
              C         IMEFF HAS PRE-75 VALUES, IMEFFC HAS CATALYST VALUES
              C
 0030               REAL STDVAD(14,2),VAD(14,2),STDUSE(14,2),USE(14,2),M(14)
              C             ARRAYS VAD AND USE ARE VEHICLE AGE DISTRIBUTION AND ANNUAL
              C             USEAGE DATA FOR CALCULATIONS. WITH 14 AGES AND 2 VEHICLE
              C             TYPES (1=CAR,2=LD TRUCK).  IF VAD AND/OR USE ARE NOT
              C             INCLUDED IN THE INPUT DATA (NAMELIST INDATA), THEN THE
              C             NATIONAL DATA IN ARRAYS STDVAD AND STDUSE WILL BE USED.
 0031               DATA STDVAD /0.081, 0.110, 0.107, 0.106, 0.102, 0.096, 0.088,
                  X              0.077, 0.064, 0.049, 0.033, 0.023, 0.018, 0.046,
                  X              0.061, 0.097, 0.097, 0.097, 0.083, 0.076, 0.076,
                  X              0.063, 0.054, 0.043, 0.036, 0.024, 0.024, 0.161/
 0032               DATA STDUSE /15900.0, 15000.0, 14000.0, 13100.0, 12200.0, 11300.0,
                  X              10300.0,  9400.0,  8500.0,  7600.0,  4*6700.0,
                  X              15900.0, 15000.0, 14000.0, 13100.0, 12200.0, 11300.0,
                  X              10300.0,  9400.0,  8500.0,  7600.0, 2*6700.0,2*4500./
              C
              C***************************************************************************
              C
 0033               REAL VMT(12), PC(2)/0.820, 0.180/
              C             ARRAY VMT CONTAINS THE VMT TO BE USED FOR EACH OF THE 12
              C             CALENDAR YEARS PROVIDED FOR; VMT SHOULD BE READ IN VIA
              C             INPUT NAMELIST INDATA, UNITS OF TRILLIONS OF VMT PER YEAR
              C             PC CONTAINS SPLIT OF LDV VMT BETWEEN AUTO AND TRUCK
              C
 0034               REAL TOTAL(2,3,12)/72*0.0/, VMTTOT(12), GRDTOT(3,12)
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                C             ARRAY TOTAL CONTAINS TOTAL EMISSION ESTIMATES FOR TWO
                C             VEHICLE TYPES, 3 POLLUTANTS, AND 12 CALENDAR YEARS. ARRAY
                C             GRDTOT HAS SAME FOR 2 VEHICLE TYPES COMBINED.  ARRAY
                C             VMTTOT CONTAINS THE VMY SUMMARY LINE FOR 12 YEARS.
                C
 0035                 DIMENSION NAME(20)
                C             ARRAY NAME CONTAINS RUN NAME IN ALPHA USED TO LABEL OUTPUT
                C
 0036                 INTEGER POLL, VEHTYP, MODYR, CALYR(12), NYR, CRNIDX, AGE
                C         POLL = POLLUTANT INDEX: CO=1, HC=2, NOX=3
                C         VEHTYP = VEHICLE TYPE INDEX: AUTOS=1, LD TRUCKS=2
                C         MODYR = VEHICLE MODEL YEAR, RANGING 1958 TO 1990
                C         CALYR = CALENDAR YEARS TO BE ESTIMATED - 12 IN NUMBER
                C         NYR = INDEX FOR CALYR, RANGING 1 TO 12 FOR 1971-80,85,90
                C         CRNIDX = WORKING INDEX RELATING MODEL YR TO CALENDAR YR
 0037                 DATA CALYR/1971,1972,1973,1974,1975,1976,1977,
                     X          1978,1979,1980, 1985, 1990/
                C
 0038                 REAL A(3),B(3),ACAT(3),BCAT(3),TEMP/55.0/
                C         CONTAINS TEMPERATURE CORRECTION FACTORS FOR 3 POLLUTANTS;
                C         A AND B FACTORS FOR REGULAR VEHICLES, ACAT AND BCAT FOR
                C         CATALYST VEHICLES (YEARS 1975-77).  TEMP IS THE AVG ANNUAL
                C         TEMPERATURE IN DEG.F, INPUT VIA NAMELIST INDATA.
 0039                 DATA A/0.0127,0.0113,0.0046/, ACAT/0.0743,0.0304,0.0060/,
                     X     B/1.95,1.81,1.36/, BCAT/6.58,3.25,1.52/
                C
 0040                 LOGICAL LSTRUN/.FALSE./, IMPROG/.FALSE./, PRNTAL/.TRUE./
                C            CONTROL VARIABLE LSTRUN=TRUE IF LAST DECK IN RUN, FALSE
                C            OTHERWISE. VARIABLE PRNTAL=TRUE IF ALL DETAILS TO BE
                C            PRINTED, FALSE IF ONLY SUMMARIES TO BE PRINTED.
                C            VARIABLE IMPROG=TRUE IF I/M PROGRAM IS ASSUMED FOR RUN.
                C            ABOVE DEFAULTS CAN BE OVERRIDDEN VIA INDATA; THEY
                C            ARE RE-SET AT THE END OF EACH DECK'S PROCESSING.
                C
                C******************************************************************************
                C
                C-INPUT DATA AND RUN CONTROL VARIABLES READ IN AS:
 0041                  NAMELIST /INDATA/DUMMY,VMT,VAD,USE,TEMP,IMPROG,PRNTAL,LSTRUN
                C
 0042                  CALL ERRSET(208,0,-1)
                C           (THIS SUPPRESSES UNWANTED UNDERFLOW MESSAGES)
                C
                C--ESTABLISH STANDARD DATA PRIOR TO READING INPUT
 0043             100 CONTINUE
                C
 0044                 DO 105 KK=1,2
 0045                 DO 105 K=1,14
 0046                 USE(K,KK) = STDUSE(K,KK)
 0047                105 VAD(K,KK) = STDVAD(K,KK)
                 C
                 C--READ INPUT DATA
 0048                    READ (5,199) NAME
 0049                199 FORMAT(20A4)
 0050                    READ (5,INDATA)
                 C
                 C--PRINT OUT EF ARRAY
                 C
 0051                    IF (.NOT.PRNTAL) GO TO 200
 0052                    DO 290 VEHTYP=1,2
 0053                    WRITE(6,298) VEHTYP
 0054                298 FORMAT ('1 EMISSION FACTOR ARRAYS --- VEHTYP =',I2)
                 C
 0055                    DO 290 POLL=1,3
 0056                290 WRITE(6,299) POLL, (CALYR(K),K=1,12),
                       X   (AGE,(EF(AGE,POLL,NYR,VEHTYP),NYR=1,12),AGE=1,14)
 0057                299 FORMAT('0  POLL =',I2/9X,12(5X,I4) // 14(I9,12F9.2/))
                 C
                 C
                 C****************************************************************************
                 C - CALCULATE EMISSIONS
                 C
 0058                200 CONTINUE
 0059                    VEHTYP = 1
 0060                201 CONTINUE
                 C
                 C-CALCULATE WEIGHTED ANNUAL TRAVEL
 0061                300 CONTINUE
 0062                    TOT = 0.0
 0063                    DO 301 K=1,14
 0064                    M(K) = VAD(K,VEHTYP)*USE(K,VEHTYP)
 0065                301 TOT = TOT + M(K)
 0066                    DO 302 K=1,14
 0067                302 M(K) = M(K)/TOT
                 C
                 C-FILL WORKING ARRAY WITH VMT DATA AND ZEROES
 0068                    DO 350 NYR=1,12
 0069                    VMTTOT(NYR) = 0.0
 0070                    CRNIDX = CALYR(NYR)-1957
 0071                    DO 320 K=1,CRNIDX
 0072                320 EMISS(NYR,K) = 0.0
 0073                    DO 330 K=CRNIDX,33
 0074                330 EMISS(NYR,K) = 0.0
 0075                    DO 340 K=1,14
 0076                    EMISS(NYR,CRNIDX-K+1) = M(K)*VMT(NYR) * PC(VEHTYP)
 0077                340 VMTTOT(NYR) = VMTTOT(NYR) + EMISS(NYR,CRNIDX-K+1)
 0078                350 CONTINUE
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                 C
                 C - PRINT OUT VMT ARRAY
 0079                  IF (.NOT.PRNTAL) GO TO 399
                 C
 0080                  WRITE(6,398) (NAME(K),K=1,20), VEHTYP, (CALYR(K),K=1,12),
                      X        (MODYR,(EMISS(NYR,MODYR-1957),NYR=1,12),MODYR=1958,1990),
                      X       (VMTTOT(NYR),NYR=1,12)
 0081               398 FORMAT('1 VMT ARRAY  (ANNUAL VMT IN 10**9)', 20A4 //
                      X  '  VEHTYP =', I2//7X,12(5X,I4)//33(I8,12F9.3/)//8X,12F9.3)
 0082               399 CONTINUE
                 C
                 C-BEGIN LOOP OVER 3 POLLUTANTS
 0083                  DO 599 POLL=1,3
 0084               500 CONTINUE
                 C
                 C-MULTIPLY VMT ARRAY BY EMISS FACTORS
 0085                  DO 510 MODYR=1958,1990
 0086                  DO 510 NYR=1,12
 0087                  AGE = CALYR(NYR) - MODYR + 1
 0088               510 EMISS(NYR,MODYR-1957) = EMISS(NYR,MODYR-1957) * 1.1
                      X                          * EF(AGE,POLL,NYR,VEHTYP)
                 C
                 C-APPLY TEMPERATURE CORRECTION (ASSUMES ALL CATALYST POST-74 CARS)
 0089                  DO 525 NYR=1,12
 0090                  DO 512 MODYR=1958,1974
 0091               512 EMISS(NYR,MODYR-1957)=EMISS(NYR,MODYR-1957)*(B(POLL)-A(POLL)*TEMP)
 0092                  DO 514 MODYR=1975,1990
 0093               514 EMISS(NYR,MODYR-1957)=EMISS(NYR,MODYR-1957)
                      X                              *(BCAT(POLL)-ACAT(POLL)*TEMP)
 0094               525 CONTINUE
                 C
                 C-REDUCE EMISSIONS IF I/M PROGRAM
 0095                  IF (.NOT.IMPROG) GO TO 540
                 C     OTHERWISE:
 0096                  DO 535 NYR=1,12
 0097                  DO 530 MODYR=1958,1974
 0098               530 EMISS(NYR,MODYR-1957)=EMISS(NYR,MODYR-1957)
                      X                          *(1.0-IMEFF(NYR,POLL))
 0099                  DO 535 MODYR=1975,1990
 0100               535 EMISS(NYR,MODYR-1957) = EMISS(NYR,MODYR-1957)
                      X                              * (1.0 - IMEFFC(NYR,POLL))
                 C
                 C-TOTAL OVER MODEL YEARS & PRINT
 0101               540 CONTINUE
 0102                  DO 545 NYR=1,12
 0103                  DO 545 MODYR=1958,1990
 0104               545 TOTAL(VEHTYP,POLL,NYR) = TOTAL(VEHTYP,POLL,NYR) +
                      X                                        EMISS(NYR,MODYR-1957)
```

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                  C
 0105                   IF (.NOT.PRNTAL) GO TO 549
 0106                   WRITE (6,590) POLL, VEHTYP, (NAME(K),K=1,20),(CALYR(K),K=1,12),
                      X         (MODYR,(EMISS(NYR,MODYR-1957),NYR=1,12),MODYR=1958,1990),
                      X         (TOTAL(VEHTYP,POLL,NYR),NYR=1,12)
 0107               590 FORMAT ('1  EMISSIONS POLL', I2, ', VEHTYP =', I2, 20A4 //
                      X          8X, 12(5X,I4) //33(I9,12F9.2/) / 9X, 12F9.2)
                  C
                  C-RECONSTITUTE VMT FOR NEXT POLLUTANT
 0108               549 DO 550 NYR=1,12
 0109                   CRNIDX = CALYR(NYR)-1957
 0110                   DO 550 K=1,14
 0111               550 EMISS(NYR,CRNIDX-K+1) = M(K)*VMT(NYR) * PC(VEHTYP)
 0112               599 CONTINUE
                  C
                  C-
                  C-THREE-POLLUTANT SUMMARY FOR 1 VEHICLE TYPE AVAILABLE HERE
                  C
 0113                   IF (VEHTYP.EQ.2) GO TO 620
                  C     OTHERWISE, RE-SET AND RETURN
 0114                   VEHTYP = 2
 0115                   GO TO 300
 0116               620 CONTINUE
                  C
                  C- COMBINED CAR/TRUCK TOTALS
 0117                   DO 625 NYR=1,12
 0118                   DO 625 POLL=1,3
 0119               625 GRDTOT(POLL,NYR) = TOTAL(1,POLL,NYR) + TOTAL(2,POLL,NYR)
                  C
 0120                   WRITE(6,698) (NAME(K),K=1,20), (CALYR(K),K=1,12)
 0121               698 FORMAT('1  COMBINED CAR/TRUCK EMISSION SUMMARY'//20A4//
                      X                    '  POLL  ', 12(5X,I4)//)
 0122                   WRITE(6,699) (POLL,(GRDTOT(POLL,NYR),NYR=1,12),POLL=1,3)
 0123               699 FORMAT(3(I4,4X,12F9.2//))
                  C
 0124                   IF (LSTRUN) STOP
                  C     OTHERWISE, RESET AND RETURN
 0125                   IMPROG =.FALSE.
 0126                   PRNTAL =.TRUE.
 0127                   DO 630 VEHTYP=1,2
 0128                   DO 630 NYR=1,12
 0129                   DO 630 POLL=1,3
 0130               630 TOTAL(VEHTYP,POLL,NYR) = 0.0
 0131                   GO TO 100
 0132                   END
```

APPENDIX D

FACT SHEETS FOR EXISTING I/M PROGRAMS

(Revised as of May 1977)

Location: Arizona

Type of Program: Contractor operated, permanent and mobile facilities, with loaded mode capabilities. Vehicle emission to comply with idle standards only.

Sites: 12 permanent sites, 36 lanes (9 "metro" stations of 3 to 5 lanes and 3 one-lane stations in outlying areas.) One mobile station.

Chronology: Voluntary testing began December 1975; became mandatory January 1976, and maintenance became mandatory January 1977.

Geographic Coverage: Maricopa (Phoenix) and Pima (Tucson) Counties, approx. 1.1 million vehicles including trucks and motorcycles.

Administering Agency: Arizona Department of Health Services

Operated by: Hamilton Test Systems, Inc.

Staff Contacts: ADHS - Fred Iacobelli, (602) 271-4548
HTS - Jack Hesse (Assistant Manager, (602) 955-9670
Dan Stone (Manager), (602) 955-9670

Capital Cost: $134,000 one-time appropriation by State.
$9.0 million to HTS, including location studies, administrative start-up, etc., as well as equipment, land acquisition, and construction.

Operating Cost: Est. $0.5 million by HTS in 1976.

Cost to Motorist: $5, includes one free retest.

Standards: HC and CO standards at low cruise, high cruise, and idle dependent on engine type (2 or 4 stroke), model year (4 stages), curb weight, and number of cylinders. Vehicles required to comply with idle emission standards only. Dynamic evaluation for diagnostic purposes. Twenty percent opacity standard for diesels. Projected 1976 stringency factor was 35 percent but approximately 45 percent of vehicles actually failed to meet standards. Revised standards for 1977 estimated to achieve a rate of 29 percent, but during the first quarter of the year only 17 percent of the vehicles did not meet standards at time of the first inspection. All 50 cc and larger engines are covered, including two strokes and diesels. Golf carts are exempted. New cars are not inspection until 1 year old. Thirteen year and older "moving exemption;" e.g., in 1977, model years 1964 and older are exempted.

Enforcement: Vehicles could not be registered without proof of inspection in 1976, or proof of passed inspection in 1977. Proof consists of embossed stamp on registration form by Hamilton. Under-hood check for tampering and PCV operation. Besides annual registration, vehicles must also be inspected at title change. Scrap and auction sales, and sales between private individuals are exempted.

Instrumentation: All Otto-cycle vehicles tested on Hamilton infrared (NDIR) exhaust analyzers for HC, CO, and CO_2. Wider range meter for two-stroke engines. Opacity testing. Clayton dynamometers. Computer link provides automatic printout of results (no engine hookup as in Riverside).

Data Collection: Vehicle ID information, all test results, lane location, time of day, etc. for all vehicles.

Mechanic Training: ADHS has conducted 2-day seminars for mechanics. Seminars held monthly.

Waiting Times: Some problems experienced at start of program, but these are expected to disappear due to optimizing hours of operation and better public awareness of all station locations. Ten minutes is the planned maximum wait during a typical peak hour. Problems experienced at end-of-month and peak hours. Total inspection time is 5 minutes.

Other Aspects: If the State should renege on its 5-year contract with Hamilton, a guarantee provides that Hamilton shall receive a sum, prorated over the remainder of the 5 years. After 5 years, the program will discontinue operation or Arizona may operate the program on its own, having to compensate Hamilton only for its nondepreciated capital holdings. The State may also continue to contract the I/M program, with Hamilton having exclusive contract rights for an ensuing 10-year period. Of the $5 inspection fee, 55¢ goes to the State. Part of this money is used for its own operating expenses and the remainder is deposited in a special fund to be used for future expansion, contingencies, etc. Hamilton's $4.45 share of the fee includes profit and program public relations.

Problems: Initial adverse public reaction.
Repeal proposition on November 1976 referendum ballot: did not pass.

Achievements: Nation's first contractor-operated program keeps cost to State minimal.

Location: California

Type of Program: State-operated permanent facilities in Riverside.
Phase I - Mandatory inspection with voluntary maintenance, loaded mode testing. (Phase I completed).
Phase II - Incorporation of idle mode test only.
Phase III - Test mode undecided.

Sites: Two sites, six lanes.

Chronology: Phase I (pilot program) - began inspections September 2, 1975; second station opened February 19, 1976. Phase II scheduled to begin January 1979, Phase III in January 1981. Under Phase II, program expands to 18 to 19 sites with a total of 43 to 45 lanes. I/M to be mandatory for those vehicles requiring registration changes and for those vehicles that fail California Highway Patrol random roadside checks. Inspection stations may be operated by a contractor, subject to legislative approval of negotiations. Phase III requires fully mandatory I/M for all registered vehicles on a yearly basis.

Geographic Coverage: Phase I - City of Riverside only (120,000 LDV's). Phases II and III will expand program to the remainder of the South Coast Air Basin (approximately 6.6. million vehicles), including the whole or parts of Riverside, San Bernardino, Los Angeles, Orange, Ventura, and Santa Barbara Counties.

Administering Agency: California Bureau of Automotive Repair - administration. California Air Resources Board - operations.

Staff Contacts: Jack Dolan and Joe Todd (916) 322-3823.

Capital Cost: $250,000 for six lanes of equipment (analyzers, dynos, computer control). Land and building of currently operating station are leased on a monthly basis.

Operating Cost: Not available.

Cost to Motorist: Free at present. Phases II and III, $7 to $8 (estimated). Waiver System - Maximum mandatory repair cost is $50 with provisions to raise it to $75 in later years if required.

Standards: Matrix of standards for three model year groups, two engine size groups, and the presence or absence of air injection. Projected stringency factor under these standards is 35 percent. Standards will be updated as required.
Vehicles 1955 and older and vehicles of gross weight greater than 6000 lbs are exempt from program.

Enforcement: Phase I - not applicable.
Phase II - changes in registration (buying, moving into state, etc.) cannot be made without passing inspection.
Phase III - annual renewal of registration and changes in registration cannot be made without passing inspection.

Instrumentation: For Phase I, most analysis equipment, including dynomometers, was manufactured by Autoscan. System uses computer data processing.

Data Collection: Odometer readings and vehicle age along with tailpipe concentrations of CO, HC, and NO_x. Computer hookup (to tailpipe and engine) permits instant diagnosis, with three-mode analysis of emission readings. Vehicle owner is provided with printout, indicating probable cause of malfunction and recommended service action. About 30 percent of the vehicles tested during Phase I did not meet standards. Data collection during Phase II will utilize highly automated techniques.

Accompanying Phase I was a surveillance program involving 650 vehicles. Results of this effort include program effectiveness, and "technical effectiveness" (vehicle thruput, waiting times, etc.). These results were used to help identify required elements for the proposed Phase II program.

Mechanic Training: California has a program of mechanic licensing.

Under Phase I, a "certificate of qualification" was required of mechanics to perform repairs resulting from the I/M program. These mechanics had to attend an orientation seminar and either:

(a) possess a California "Class A" mechanic's license, or

(b) pass a written examination.

Currently developing master plan to qualify mechanics in the S.C.A.B. prior to Phase II.

Waiting Time: No problems during Phase I where demand was kept uniform by mailing out notices to 450 to 500 vehicle owners daily (chosen at random by computer). The owner then had 2 weeks from date of postmark to bring in his vehicle.

Total inspection time is about 7 minutes.

Waiting time objective for Phase II is less than 10 minutes for most vehicles and an absolute maximum of 20 minutes during peak periods.

Problems: No action at this time on I/M in remainder of State.

Achievements: Public reaction has been excellent. Unique combination of exhaust analysis, engine monitoring, and computer technology. Diagnosis helps insure satisfied consumer.

Location: Chicago

Type of Program: City-operated vans, idle mode. Mandatory inspection with no enforcement = voluntary inspection. Voluntary maintenance.

Sites: Five permanent sites with two lanes each; plus six mobile sites with two lanes each. Permanent sites have varied in past years with a high of 9.

Chronology: Began inspection in June 1973. EPA Region V issued enforcement (s 113) order to city to meet inspection rate of 3000 vehicles/day by December 1975. If failing to comply, mandatory inspection and maintenance of all Chicago and Cook County vehicles entering Loop was to commence March 1976. One year later, Chicago has not met established rate and EPA has not initiated action.

Geographic Coverage: City of Chicago only (1.0 million LDV's), but any vehicle coming in will be inspected. Remainder of Cook County is far behind in implementation.

Administering Agency: City of Chicago, Department of Environmental Control.

Staff Contact: John Winkler - (312) 744-7154; Joe Seliber (312) 744-5958.

Capital Cost: $2 million, including $350,000 design and start-up.

Operating Cost: 1977 Budget: $1.448 million.

Cost to Motorist: No fee collected at time of inspection. Portion of annual city vehicle registration fee allocated to cover program costs.

Standards: CO and HC standards for four model-year groups - estimated 30 to 35 percent stringency factor.

Enforcement: None, although Vehicle Emission Testing Ordinance adopted by City of Chicago during 1973.

Instrumentation: 18 Sun #910 I Analyzers, modified to include CO_2 testing and computer control. Eleven backups w/o CO_2 modification.

Data Collection: Record kept on emissions by Make and by Model year, especially late model years 1975 to 1977's which are failing at above 25 percent. Study done during 1975 to 1976 in conjunction with EPA's Emission Factor Program showed 1975's failing at 28 percent (on Chicago test).

Mechanic Training: Definite need, but none to date.

Waiting Times: No problems.

Problems: Recent figures show less than 20 percent of city's registered vehicles are being inspected.

City position favors mandatory I/M programs with three conditions:

1. Federal Government and Auto Manufacturers concurrence on a warrantee program. (See 207(b) of Clean Air Act).
2. Auto Manufacturers compliance with statutory emissions standards.
3. I/M to be implemented regionally because of the large percentage of travel on city streets by non-Chicago vehicles.

Achievements: Communication channels established with Auto Manufacturers regarding high emission levels of late model vehicles.

Location: Cincinnati and Hamilton County, Ohio

Type of Program: Municipally-operated permanent facilities, idle mode, mandatory inspection and maintenance.

Sites: Cincinnati - One site, four lanes, includes safety inspection.

Norwood - One site, one lane, includes safety inspection.

Hamilton County - Two sites (Newtown and Glenway), three lanes total, no safety inspection.

Chronology: Fully mandatory I/M began in Cincinnati and Norwood on January 1, 1975, with no voluntary phase-in periods. Newtown began operation 8-75 and Glenway 9-75. Operations ceased at Newtown and Glenway, February 1, 1976.

Geographic Coverage: Eventually the whole of Hamilton County, about 500,000 LDV's.

Administering Agency: Individual local governments.

Area Contact: Marion Smith, (513) 352-4880 (Cincinnati)
None (513) 632-8222 (Hamilton County)

Capital Cost: (Cincinnati) $12,600 for 9 analyzers - inspection facilities already in operation for safety.

Operating Cost: (Cincinnati) $130,000 for 11 additional positions.

Cost to Motorist: $3.75, including safety.

Standards: Same as Chicago, four-stage standards dependent on model year - stringency factor 25 percent in 1975 and 18 percent in 1976 and first quarter of 1977.

Enforcement: (Cincinnati) Vehicle cannot be registered by city (sticker issued) unless inspection is passed. City Division of Air Pollution Control has four vehicles issuing tickets on a limited basis. Enforcement had been inadequate due to lack of Police Department backing and difficult due to the inability to distinguish between Cincinnati vehicles and Hamilton County commuter vehicles. However, during 1976 enforcement was stepped up with nearly 80,000 citations issued by Cincinnati and Norwood police.

(Hamilton County) No enforcement program. Recently cited by Federal Government with court action pending.

Instrumentation: Sun #910 I analyzers modified with color-coded scales and pass/fail lights. Cincinnati has 9 of these, Norwood 2, and Hamilton County 4.

Data Collection: Records kept on volumes passing and failing only. Percent of vehicles not meeting standards are as follows:

	1975 %	1976 %	1977[a] %
Cincinnati	21.5	16.9	17.6
Norwood	31.8	19.7	

[a] First quarter.

Mechanic Training: None at present, but need exists. Region V is planning courses and Colorado State University has been contacted. City has responded favorably to letter by Region concerning program.

Waiting Time: No major problems.

Problems: Woefully low throughput caused by no enforcement and lack of "tradition of inspection," caused Hamilton County to cease operations February 1, 1976.

Lack of phase-in period and adequate PR caught public by surprise. Complaints that Kentucky commuters should be tested. (Kentucky is establishing a voluntary I/M program during 1977 in the Kentucky portion of the Cincinnati metropolitan area).

Achievements: Demonstrated short lead time adding I/M to existing safety program.

With improved enforcement, approximately 90 percent of registered LDV's in Cincinnati complied with I/M requirements during 1976.

Location: New Jersey

Type of Program: State-operated permanent facilities, idle mode, mandatory inspection and maintenance. Includes safety inspection. Failed vehicles may be retested at certified private garages, for $1.00 certificate fee plus labor charges.

Sites: 38 sites, 68 lanes, one mobile van (rotates among sites).

Chronology: Inspections began July 1972, with voluntary maintenance phase. Fully mandatory program commenced February 1, 1974, with Phase I standards. On November 1, 1975, Phase II standards became effective, and private garage reinspection began a 2-year trial period. Also beginning on this date, new cars were withheld from inspection for their first 2 yearly re-registrations. Phase III standards, originally scheduled to become effective on February 1, 1976, were postponed until at least January 1977. Phase III now subject to public hearings and final review.

Geographic Coverage: Entire State of New Jersey (3.9 million LDV's).

Administering Agency: New Jersey Department of Environmental Protection (establishes standards and technical procedures), Department of Motor Vehicles (administers testing and enforces standards).

Staff Contact: John Elston, NJDEP, (609) 292-6714.

Capital Cost: $250,000 for analyzers and related equipment-inspection facilities already in operation for safety.

Operating Cost: DEP, $330,000/yr
DMV, $1,000,000/yr
Total $1,330,000/yr

Cost to Motorist: $2.50, taken out of yearly registration fee, includes safety.
$1, additional fee at reinspection garages for certificate, garage labor charges extra.

Standards: Phase I - approx. 12 percent stringency factor.
Phase II - approx. 16 percent stringency factor.
Proposed Phase III - approx. 23 percent stringency factor.
All phases are four-stage, dependent on model year.

Enforcement: Vehicle cannot be registered unless inspection is passed. Enforced by sticker system. Proposed HDV standards to be enforced on the road (pullover spot check) and at operators' facilities.

Instrumentation: 125 specially modified Sun "EET 910" analyzers w/color-coded scales and pass/fail lights.

Replacement equipment purchase budgeted for FY78.

Data Collection: Records kept for initial emissions test. Initial refailure rate of 40 percent had dropped to 18 percent during Phase I. Phase II refailure rate has stabilized at 25 percent. NJDEP also conducts periodic surveillance on groups of 1000 vehicles.

Mechanic Training: Training program to be conducted at vocational schools starting fall 1977. Program instructors trained during spring 1977.

Plans to certify mechanics through NIASE. Exxon has already conducted mechanic training for emissions, affecting about 15 percent of all service stations in state.

Waiting Times: Major delays predated the advent of emission inspection and continued into both emission Phases I and II. Delays cause many vehicles to needlessly fail the CO emissions test because of the "hot idle" effect. These vehicles return to be retested for CO, making waiting lines even longer.

Problems (other): Two year exemption for new cars means approx. 30,000 miles pass before cars are first inspected. Lack of capital - capacity improvements cannot be made.

DMV resistance to the incorporation of Phase III standards. Refailure rate has stabilized at 25 percent - considered unsatisfactory.

Achievements: Nation's longest ongoing I/M program. Thirteen percent improvement in ambient CO readings since program began. This reduction is holding. Four thousand, two-hundred garages have installed exhaust analyzers (as of January 1977). This number has risen with the inception of the private garage reinspection program.

Location: Nevada

Type of Program: Idle test by licensed service stations, garages and auto dealers, includes check and adjustment of primary vehicle specifications.

Sites: Approximately 120 to 125 licensed private stations located in Clark County, Nevada.

Chronology: Pilot testing and inspection program initiated July 1974 for change of ownership vehicles in Clark County. Annual inspection program scheduled for July 1, 1975, postponed. State Environmental Commission directed to conduct a thorough study of a compulsory annual I/M program. Nevada Assembly Bill 464 effective July 1, 1977. Mandatory I/M in all counties with population greater than 100,000 to be phased in by July 1, 1979.

Geographic Coverage: Presently Clark County only, light-duty vehicle population about 200,000. Annual Inspection and Maintenance to be established in both Clark and Washoe Counties by July 1979.

Administering Agencies: Department of Motor Vehicles
Department of Human Resources

Staff Contacts: E. J. Silva, Vehicle Compliance and Enforcement Section, D. M. V. (702) 885-5396.

Capital Costs: Not reported. D. M. V. outfitted with exhaust analyzer, calibration gases and pick-up truck.

Operating Costs: Recovered from fees - $2 - Certificate of Compliance fee
$25 - Annual station license fee.

Cost to Motorists: Inspection fee equal to sum of $2 certificate fee plus labor charges. Total fee ranges from $8.50 to 17.00 due to variations in prevailing shop labor rates. Stations permitted to set own fee with D.M.V. approval.

Standards: CO and HC standards for three model-year groups.

Enforcement: Vehicles cannot be registered without Certificate of Compliance.

Instrumentation: Nevada list of approved exhaust gas analyzers.

Data Collection: Vehicle description, motor vehicle specification settings, and CO and HC tailpipe concentrations.

Mechanic Training: No formal program as such but for mechanics to be licensed as "Approved Inspector;" they must provide documentation of automotive schooling and experience, must be qualified to operate emissions analyzing equipment, and pass written examination.

Station Licensing: To become an "Authorized Station: to perform emission test, a station must employ an "Approved Inspector," own proper tools and equipment for performing test and present a $1000 surety bond.

Waiting and Test Time: No problems. During change of ownership phase most vehicles are conveyed by dealers who perform inspection and required adjustments as routine task of vehicle preparation. Nevada inspection requires about 15 to 20 minutes.

Problems: Minimal.

Achievements: Consumer complaints have been minimal. Unique combination of inspection testing and check and adjustment of primary manufacturer's specification settings. Most vehicles attain at least some improvement in terms of performance, emission reductions, and fuel savings.

D.M.V. control of licensings of stations and inspectors including regular visits to check station performance, tools and emission analyzing equipment.

Location: Portland, Oregon

Type of Program: Combination of permanent and mobile facilities, idle mode, mandatory inspection and maintenance. Inspection is biennial at present.

Sites: Five permanent sites, 10 lanes; four mobile vans, five lanes Nine sites, 15 lanes total. Plans call for expansion to 17 lanes.

Chronology: Voluntary inspection and maintenance commenced January 1974. In 18 months, 105,000 vehicles were tested. No transitional mandatory/voluntary phase. Fully mandatory I/M began July 1, 1975.

Geographic Coverage: Portland Metropolitan Service District - urbanized portions of Washington, Multnomah, and Clackamas Counties (580,000 LDV's ≤ 8400 lbs).

Administering Agency: Oregon Department of Environmental Quality (DEQ).

Staff Contact: Ron Householder, (503) 229-6200.

Capital Costs: Total cost of analyzers (29) was about $200,000. Only one station was actually built for the program, construction costing $77,000. Located on State right-of-way, land costs are not included. This station has loaded-mode and safety testing capabilities. The four remaining permanent facilities are leased. A complete mobile van setup, including new vehicle, three analyzers, and secondary equipment, cost $40,000 in 1975.

Operating Costs: Approx. $1.45 million for "on" year, $0.8 million for "off" year.

Cost to Motorist: $5 for issuance of Certificate of Compliance. Unlimited retests.

Standards: Multiple standards, based on manufacturer's specifications, involving model year groups, manufacturer groups, and engine modifications. Testing involves preconditioning to offset hot idle effect. Vehicles can also be rejected for exhaust dilution, visible smoke, and excessive idle speed. Stringency factor is about 35 percent.

Enforcement: Vehicles cannot be registered without Certificate of Compliance.

Instrumentation: 29 Sun "OEA 75" analyzers with digital readout of HC, CO, and CO_2, and with remote viewing gauges. Systems are fully computer compatible, but are not computer controlled at this time. For supplementary data generation, two Clayton and two Autoscan dynomometers are used. Oregon State University has CVS testing capabilities.

Data Collection: Actual stringency factor, July 1975 to March 1977, was 36 percent. Survey of 3570 vehicles during February to March 1977 found refailure rate of 22 percent, up from 16 percent reported earlier.

Record kept of all emission readings. Readings are taken at idle speed, 2500 rpm (intended mainly as preconditioning), and then again at idle, with the lower of the idle readings governing.

Mechanic Training: Emission-related tune-up course at Clackamas Community College, in response to Oregon I/M. EPA Region X assisted with funding through DEQ. Several hundred enrollees in the past 2 years.

An increase in training by major service station parent organization has been noted. Other community colleges and vocational school have established self-initiated training programs. DEQ is proposing to conduct mechanic training seminars.

Waiting Time: Systemwide average waiting time approximately 15 minutes during 1976 ("on" year). Total inspection time averages 3 minutes.

Other Aspects: Inspections tied into biennial motor vehicle registration system. Even numbered years are "on" years with approximately 80 percent of LDV registrations due for renewal, and odd numbered years are "off" years with remaining 20 percent due for renewal. Inspection stations were opened 7 days/week during 1976 with 75 emission inspectors on payroll. During 1977, stations opened 5 days/week, Tuesday through Saturday. Only 23 emission inspectors required to inspect "off" year (1977) demand. Licensed private fleets (more than 100 vehicles) may inspect themselves. Inspection of HDV's proposed for 1978.

Problems: The 2-year inspection interval hurts program effectiveness, cash flow, and creates personnel problems. It will be at least July 1977 before interval can be shortened legislatively. (No action expected at this time). Public criticism of "lack of uniformity" - Portland area residents feel that commuters from Washington State should be tested, as well as vehicles in the remainder of Oregon. Some evidence of vehicle being readjusted following the passing of inspection due to driveability problems.

Achievements: Estimated reduction in CO and HC emissions of 14 percent and 7 percent, respectively, have been achieved during first inspection cycle.

Many garages are buying analyzers, indicating increased acceptance. Of all I/M programs, has the most extensive, and therefore the most equitable standards. Difficulties in identifying vehicles and their standards have been minimal.

Location: Rhode Island

Type of Program: Idle test by certified private garages. Performed in conjunction with safety inspection.

Sites: Approximately 1000 private garages statewide.

Chronology: Inspection begins November 1977 with voluntary maintenance. Fully Mandatory I/M program commences November 1978.

Geographic Coverage: Entire State of Rhose Island (0.5 million LDV's)

Administering Agency: Rhode Island Department of Transportation.

Staff Contract: Wendall Flanders, Chief, RIDOT, (401) 277-2481.

Capital Costs: $1,000,000 (includes first year operating costs) for construction of State-Run Challenge Lane Facility. Capital to be repaid from inspection fee.

Operating Costs: First year included in Capital Cost appropriation.

Cost to Motorist: $4.00 inspection fee - $1.00 to state, $3.00 to private garage.

Standards: Not set as of May 1, 1977.

Enforcement: Windshield stickers, staggered basis.

Instrumentation: Approved list of exhaust analyzers.

Data Collection: Not set. Proposed use of mark-sense computer forms.

Mechanic Training: Existing programs at Vocational School System based on EPA approved program developed at Colorado State University.

Waiting Time: No experience.

Other Aspects: Challenge lanes for inspection of state-owned vehicles and for checks of contested inspections of private vehicles.

Problems: Originally intended to use centralized test lane approach operated by a private contractors.

Achievements: Program initiated and supported by Governor and RIDOT with backing from Executive and Legislature Branches.

APPENDIX E

BIBLIOGRAPHY

The bibliography is broken down by major topics. An asterisk (*) denotes a recommended source. It is recommended that these reports be read first when seeking information on inspection/maintenance.

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APPENDIX F

GLOSSARY

GLOSSARY

Accuracy	The degree by which an instrument is able to determine the true concentration of a pollutant in the exhaust gas sampled.
Air Contaminants	Any fumes, smoke, particulate matter, vapor gas, or any combination, but excluding water vapor or stream condensate.
Ambient Air	The surrounding or outside air.
Calibration Gases	A blend of HC and CO gases using nitrogen as a carrier gas.
Carbon Monoxide	A nonirritating, colorless, odorless gas at standard conditions which has the molecular form of CO.
Certificate of Compliance	A document which is issued upon completion of the inspection which records the results of the inspection and serves as proof of said inspection for vehicle owner.
Certified Mechanic	An individual licensed to install, repair and adjust motor vehicle engine emissions related components and pollution control devices in order that the motor vehicle meet applicable emissions standards.
Certified Station	A private facility licensed to install, repair and adjust motor vehicle engine emissions related components and pollution control devices in order that the motor vehicle meet applicable emissions standards.
Chassis Dynamometer	A machine equipped with two parallel rollers which support the rear wheels of a motor vehicle. When positioned on the dynamometer the vehicle may be "driven" to simulate the loadings the engine would experience when the vehicle is operated on the road. A power

	absorption unit is connected to the rollers to simulate the loading from the various sources of fluid and mechanical friction present during road operation. Weights can also be coupled to the rollers to simulate the inertial effects of vehicle mass during acceleration and deceleration.
Crankcase Emissions	The products of combustion emitted into the ambient air from portions of the engine crankcase ventilation or lubrication system.
Drift	The amount of meter reading change over a period of time. Zero drift refers to change of zero reading. Span drift refers to a change in reading of a calibration point on the upper half of the scale. The calibration point is established by reading a calibration gas of known concentration.
Emission Inspection Program	An inspection and maintenance program in which each vehicle is subjected at specified intervals to a test of its emissions under specified conditions. The emission levels are compared with a standard established for the vehicle class. If the emissions are higher than the standard, the vehicle is failed and must be adjusted or repaired to bring its emissions into compliance with the standard.
Exhaust Gas Analyzer	An instrument for sensing the amount of air contaminants in the exhaust emissions of a motor vehicle.
Exhuast Emissions	The products of combustion emitted into the ambient air from any opening downstream of the exhaust ports of a motor vehicle engine.
Fleet Owner Authorized Stations	A permit issued to a qualified fleet owner to perform vehicle emissions inspection limited to his fleet only.
Fleet Operator	The owner of a fleet of a designated number of vehicles.
Hang-Up	HC which clings to the surface of the sampling and analyzer system in contact with the gas sample stream which causes an erroneous indication of HC in the measured value.

Heavy-Duty Vehicle	Any motor vehicle designed for highway use which has a gross vehicle weight of more than 8,500 pounds.
Hydrocarbons	A compound whose molecular composition consists of atoms of hydrogen and carbon only, HC.
Idle Test	An emission inspection program which measures the exhaust emission from a motor vehicle operating at idle. (No motion of the rear wheels). A vehicle with an automatic transmission may be in drive gear with brakes applied or in neutral gear.
Independent Contractor	Any person, business firm, partnership or corporation with whom the state may enter into an agreement providing for the construction, equipment, maintenance, personnel, management and operation of official inspection stations.
Inspection and Maintenance Program	A program to reduce emissions from in-use vehicles through identifying vehicles that need emissions control related maintenance and requiring that maintenance be performed.
Inspection Station	A centralized facility for inspecting motor vehicles and pollution control devices for compliance with applicable regulations.
Inspector	An individual who inspects motor vehicles and pollution control devices for compliance with applicable regulations.
Instrument	The system which samples and determines the concentration of the pollutant gas.
Key Mode Test	A loaded mode test in which exhaust emissions are measured at high and low cruise speeds and at idle. The cruise speeds and dynamometer power absorption settings vary with the weight class of the vehicle. The dynamometer loading in the high cruise range is higher than normal load in order to more effectively expose malfunctions leading to high emissions.

Light-Duty Vehicle	A motor vehicle designed for highway use of less than 8501 pounds gross vehicle weight. Further distinctions are sometimes made between light-duty automobiles and light-duty trucks such as pickup trucks.
Loaded Mode Test	An emission inspection program which measures the exhaust emissions from a motor vehicle operating under simulated road load on a chassis dynamometer.
Model Year of Vehicle	The production period of new vehicle or new vehicle engines designated by the calendar year in which such period ends.
Motor Vehicle	Any self-propelled vehicle which is designed primarily for travel on public right of ways and which is used to transport persons and property.
Motorcycle	A motor vehicle having a seat or saddle for use of the rider and designed to travel on not more than three wheels in contact with the ground, but excluding a tractor.
Positive Crankcase Ventilation	A system designed to return blowby gases from the crankcase of the engine to the intake manifold so that the gases are burned in the engine. Blow-by gas is unburned fuel/air mixture which leaks past the piston rings into the crankcase during the compression and ignition cycles of the engine. Without positive crankcase ventilation these gases, which are rich in hydrocarbons, escape to the atmosphere.
Prescribed Inspection Procedure	Approved procedure for identifying vehicles that need emissions control realted maintenance.
Registered Owner	An individual, firm, corporation or association whose name appears in the files of the motor vehicle registration division of the department of motor vehicles as the person to whom the vehicle is registered.
Repeatability	The instrument's capability to provide the same value for successive measures of the same sample.

Response Time	The period of time required by an instrument to provide meaningful results after a step change in gas concentration level initiated at the tailpipe sample probe.
Smoke	Small gasborne and airborne particles, exclusive of water vapor, arising from a process of combustion in sufficient number to be observable.
Stringency Factor	The percentage of total vehicles tested in an inspection/maintenance program in a given time period that fail inspection and are required to have maintenance performed.
Vehicle Dealer	An individual, firm, corporation or association who is licensed to sell motor vehicles.
Vehicle Emissions Standard	A specific emission limit allowed for a class of vehicles. The standard is normally expressed in terms of maximum allowable concentrations of pollutants (e.g., parts per million). However, a standard could also be expressed in terms of mass emissions per unit of time or distance traveled (e.g., grams per mile).

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